SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MARCH 1902.

GENERAL PHYSICS.

425. *Slide-rule.* **R. Proell.** (Zeitschr. Instrumentenk., Beib. 22. pp. 213–215, Nov. 15, 1901.)—The common objection to a long slide-rule is its unwieldiness; the objection to a short one is lack of precision. It is here shown that the logarithmic scale can be arranged in what is called "table form," *i.e.*, in a number of parallel lines of equal length, equally spaced with respect to one another, drawn from the same straight line. Using ten of these lines, the author obtains, within convenient dimensions, a logarithmic scale of 1·20 metres. Two such "tables" are used in combination, an upper and a lower; the logarithmic scale in one beginning from left to right, and in the other from right to left. With this arrangement great accuracy is claimed; square-roots and cube-roots are said to be obtained easily to four decimal places. R. A.

426. *Balance Immersed in Water.* **G. Guglielmo.** (Accad. Lincei, Atti, 10. pp. 259–268, Dec. 1, 1901.)—The paper describes the construction and theory of a balance used under water to determine densities. As the weight of the balance in water can be made extremely small, the friction on the knife-edges is small, and these are, moreover, lubricated by the water. On this account the balance can be made far more sensitive than the ordinary balance, and in determinations of density the error due to surface tension on the suspending wire is avoided. The construction shown is very simple; the balance arm is made of glass, with a central bulb of such a size as to give the whole balance a suitable weight. The knife-edges of the ordinary balance are replaced by points resting on planes. G. H. B.

427. *Recording Rain-gauge.* **P. Lancetta.** (Elettricità, Milan, 20. pp. 775–777, Dec. 7, 1901.)—Between the funnel and receiver of an ordinary rain-gauge is fixed a chamber containing a little water-wheel with six buckets. The water from the funnel drops into one bucket, which, when full, slips past a spring catch; the next bucket then takes its place. The axis of the wheel carries a disc with six contact pieces, so that every time a bucket is filled an electric contact is made, and a mark registered on a chronometer tape. G. H. B.

428. *Nitrometer.* **G. Oddo.** (Accad. Lincei, Atti, 10. pp. 268–269, Dec. 1, 1901.)—In determining the quantity of nitrogen in organic substances, the method of freeing the combustion tube of air by carbonic anhydride, and collecting the nitrogen in Schiff's nitrometer, gives results somewhat too high. On the other hand, the method employing a vacuum pump and concentrated potash solution, though more exact, is troublesome and lengthy. The author has so modified Schiff's nitrometer that it can be applied to a Sprengel pump, and thereby combines the advantages of the two methods. The nitrometer consists of a graduated tube, closed at the bottom, and with a tap at the top. Near the bottom are three side tubes, one is for attaching to the pump, and serves for the introduction of mercury and gas, the second is for withdrawing the mercury, and the third is for the potash solution.

G. H. B.

429. *Tachometry.* **J. A. Fleming.** (Cassier, 21. pp. 37–40, Nov., 1901.) —In addition to general remarks on the subject, and a short account of the stroboscopic method, the author strongly advocates the employment of a hydraulic speed indicator which is in use in his laboratory. A small, circular, centrifugal pump, consisting of a four-bladed brass fan, with blades parallel to the fan shaft, enclosed in a cylindrical brass case, just clearing the blades, has its fan shaft geared to the wheel or shaft whose angular velocity is to be recorded. The pump chamber communicates, through an opening near the shaft, with a reservoir of water, and, through an opening in the cylindrical surface, with a vertical glass tube. The height of the liquid in the tube will then be proportional to the square of the angular velocity to be determined. The fan shaft glands require packing watertight against a very slight pressure only, and the arrangement is very sensitive. Moreover, the greater the speed, the greater will be the actual variation in height in the column of liquid corresponding to a given percentage variation in the speed. It also has the advantage that the glass gauge tube need not be near the pump. For example, if used for electric machinery, the gauges may be affixed to the switchboard. The author has found it possible, by means of this arrangement, to control the speed of alternators to within a quarter of 1 per cent.

G. W. de T.

430. *Resistance to Motion in Fluids.* **F. Ahlborn.** (Phys. Zeitschr. 3. pp. 120–124; Discussion, p. 124, Dec. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg, 1901.)—The author attaches one or several plates under various angles to a carriage, driven by an electric motor, regulated by a flywheel and electric and mechanical resistances, through a trough filled with water into which lycopodium seed or sawdust is being strewn. A camera is fixed on the carriage, and is moving with the plate, so that the flashlight photographs show the plate stationary and the water in motion. The plates were either dipping into the water, in which case the surface tension has to be overcome, or totally immersed in the water; in the latter case mirrors were inserted in the sides and bottom of the trough. Practically the same stream line diagrams resulted in both cases. The author then coloured the water and lowered and raised the cardboard plates while in motion. In this way he obtained profile diagrams of the rise and fall of the water in front and rear of the plate. The front wave is flat, but falls off towards the edges without reaching the zero line; the rear wave is a kind of lemniscate. The author makes relief models of these waves. All these

phenomena are in close analogy with observations made in air by L. Mach, Marey, and Recknagel.—The discussion by **König** and **Grimsehl** concerned the agreement of the experiments with Rayleigh's formulæ. H. B.

431. *Attraction to a Vibrating Surface.* **R. Geigel.** (Ann. d. Physik, 6. 4. pp. 856–860, Dec. 5, 1901.)—In an electroscope in which a leaf of metal-foil hangs on each side of a brass plate connected with the knob, the author noticed that when the knob was tapped the two leaves were attracted to, and held against, the brass plate, and fell back free after a few seconds. The article describes experiments made to ascertain the cause of this phenomenon. In a vacuum it does not occur, and depends, therefore, on some action of the air. The same phenomenon was observed by holding a strip of paper near one prong of a vibrating tuning-fork; the paper fell away while the fundamental note was still audible. Lycopodium sprinkled on the prong gathered itself into spheres, which were not thrown off the fork, but kept up a very lively and rapid motion for a certain time, and then settled down into discs. Their motion ceased after the same length of time, during which a paper strip was attracted to the prong, and the author concludes that both phenomena are due to the same cause, namely, to very rapid vibrations, which, from the distance separating the lycopodium spheres, he estimates at 32,250 per second. G. H. B.

432. *Optical Methods of Observing Diffusion.* **J. Thovert.** (Comptes Rendus, 133. pp. 1197–1199, Dec. 23, 1901.)—Observations of the deviations of horizontal beams of light in diffusing solutions at different levels and at different times give the values of k, the coefficient of diffusion. If c be the concentration, x the level, h the whole height of the column, and n a whole number,

$$\frac{dc}{dx} = \sum_{n=1}^{n=\infty} \mathrm{A}_n \sin\frac{n\pi x}{h^2}\,\varepsilon^{-\frac{n^2\pi^2}{h^2}kt}$$

When t is long enough, dc/dx varies sensibly with $\sin\frac{\pi x}{h}$ at a given time, and with $\varepsilon^{-\frac{\pi^2}{h^2}kt}$ at a given level; this occurs in, say, 72 hours. Observations at one level at times t_1, t_2, thereafter give deviations Δ_1, Δ_2, such that—

$$k = \frac{h^2}{a^2}\,\frac{\log\Delta_1 - \log\Delta_2}{t_1 - t_2}$$

If the solution and the distilled water each occupy exactly one-half the column, the even terms in the value of dc/dx disappear; and at the level $h/3$ or the level $2h/3$ the third term also disappears; so that at these levels the condition favourable as above to the estimation of k is very rapidly attained. If in this case the deviations be observed at levels $h/6$, $h/3$, and $h/2$, the sum $\Delta_{h/6} + \sqrt{3}\Delta_{h/3} - \Delta_{h/2}$ is proportional to $\varepsilon^{-\pi^2 kt/h^2}$ from the outset; so that the required observations at two times, t_1 and t_2, may be speedily secured. A. D.

433. *On some Problems of Elastic Equilibrium.* **O. Tedone.** (Accad. Lincei, Atti, 10. pp. 251–258, Dec. 1, 1901.)—The author imagines an elastic solid bounded by that part of the plane of $\eta\zeta$ which contains positive ζ (the plane σ_1), and part of the plane of $\xi\eta$ which contains positive ξ (the plane σ_2). Suppose four points, A, A$_1$, A$_2$, A$_3$, forming a square whose sides are parallel

to ζ and ξ, and of which A is the point ξ, η, ζ, and A_3 is $\xi, \eta, -\zeta$. He takes r, r_1, r_2, r_3 as the distances of any point from A, A_1, A_2, A_3 respectively. The displacements of any point in the solid are u, v, w, and are supposed to have given values on the planes σ_1 and σ_2. The problem then is to determine u, v, w at any point in the solid. He obtains the general equations of equilibrium in the form—

$$\Delta^2 u = -\frac{\lambda+\mu}{\mu}\frac{\partial\theta}{\partial\xi},\ \Delta^2 v = -\frac{\lambda+\mu}{\mu}\frac{\partial\theta}{\partial\eta},\ \Delta^2 w = -\frac{\lambda+\mu}{\mu}\frac{\partial\theta}{\partial\zeta},$$

where λ and μ are Lamé's constants, and—

$$\theta = \frac{\partial u}{\partial\xi} + \frac{\partial v}{\partial\eta} + \frac{\partial w}{\partial\zeta}.$$

Hence, using functions of the form $(1/r - 1/r_3)$, &c., and by the application of Green's and analogous theorems, u, v, w at ξ, η, ζ are determined in terms of the given values of u, v, w on the planes σ_1 and σ_2. It is impossible to represent the work, which is purely mathematical, adequately in an abstract.
S. H. B.

434. *Viscosity of Solutions Containing only Organic Substances.* **C. Schall.** (Phys. Zeitschr. 3. pp. 62–63, Nov. 15, 1901.)—Measurement made to test a formula of G. Jäger's (Wien. Akad. Ber. B. CIII. Abt. IIa, 245). As solvents aqueous glycerine and thymol were used.
F. G. D.

435. *Relative Determinations of Gravity.* 1. *Determinations at ten Stations on the Meridian of Tübingen.* **K. R. Koch.** (Zeitschr. Instrumentenk. 21. pp. 269–271, 1901. From the Jahreshefte d. Ver. f. Vaterländ. Naturkunde in Württemberg, p. 356, 1901.)—This paper deals with results for ten of the ninety gravity stations of Württemberg. The author describes pendulum experiments to determine the difference in the values of gravity at each of those ten stations, and its value at the base-station at Stuttgart. The stations lie on the same meridian. At the same time as an observation was being made at any station, a second observer took observations of a pendulum at Stuttgart, the two stations being electrically connected, so that the *same* chronometer (a Kutter precision-chronometer) served for both. This obviated the necessity for determining the rate of the chronometer. A special support devised by the author and possessing exceedingly great rigidity was used, and the temperature constants of the pendulums employed were carefully determined. A table of results gives the latitude of each station, the latitude of the base-station at Stuttgart, and the excess of the observed value of gravity over its calculated value for all the stations. This excess increases from 0·01 cm. per sec. per sec. at Bitz (latitude 48° 10′ 30″) to 0·07 cm. per sec. per sec. at Fürfeld (latitude 49° 12′ 35″). The mean longitude of the stations is 9° 5′ east of Greenwich.
W. S.

436. *Thermoelectric Determination of Underground Temperatures at the Museum of Natural History.* **H. Becquerel.** (Comptes Rendus, 133. pp. 800–803, Nov. 18, 1901.)—One junction, B, of an iron-copper circuit which includes a Deprez-d'Arsonval galvanometer, is exposed to the unknown temperature; the other junction, A, may be at any constant known temperature, t_0—not conveniently at 0° as in the A. C. Becquerel arrangement of 1826. The scale of the galvanometer is calibrated so that temperatures corresponding to currents may be read off directly. The circuit being open, the scale is now moved parallel to itself so that the zero of the galvanometer coincides with the figure indicating the temperature t_0. On closing the circuit, the beam of light is thrown on to the figure which marks the temperature of the junction B. D. H.-J.

437. *Heat Exchange in the Soil, the Water, and the Atmosphere.* **J. Schubert.** (Phys. Zeitschr. 3. pp. 117–119, Dec. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg, 1901.)—The author makes use of observations covering different periods, made by himself in different soils at Eberswalde; by Homén in Finland; by Petterson on the East Sea (maximum depth 55 m.) and North Sea (200 m.); at the Danish lighthouse stations, in the Hintersee in Prussia, and in the balloon ascents from Paris, after Hann. Though the data are uncertain, they show that the Baltic takes up, per unit area, during summer, from twenty to thirty times, and the North Sea thirty to forty times as much heat as the firm land, and that the heat exchange in the atmosphere is (at Paris) 3/2 times that of sandy soil, 1/15 that of the Baltic, and 1/25 of the North Sea. In the case of water we have not only to consider heat capacity and evaporation. This is apparent from the behaviour of wet moors and sand. Wet moors have a high heat capacity, almost as high as water, and evaporate much more water than sandy soil, the wet surface becoming very warm; but the heat does not penetrate deep, and the moor takes up less heat than sand. In open water the temperature fluctuations penetrate to great depths; in the Kattegat the yearly temperature variation is still 8° at a depth of 26 m. Firm soil becomes hot on warm days and in warm seasons, and gives off much heat to the air, but it stores up little heat and cools rapidly. The sea stores up the heat; its surface does not get hot, little heat is imparted to the air, and the heat is replenished from the depth during the cold season. The temperature maximum and minimum respectively of the soil are in September and March, of the air and water in August and February. The maximum heat absorption occurs in May (soil and air) or June (water), the maximum heat loss in October or November, when the surface of the sea is about 2° warmer than the air above it; the yearly mean excess of the temperature of the sea surface over that of the air amounts to more than 0·5°. H. B.

438. *Meteorological Observations with Kites at Sea.* **A. L. Rotch.** (Science, 14. pp. 896–897, Dec. 6, 1901.)—While crossing the Atlantic from Boston to Liverpool, the author could fly kites on five out of eight days, and obtained records of the atmospheric pressure, temperature, humidity, and wind velocity for heights up to 2,000 feet. The temperature fell rapidly over the sea with increasing height; otherwise the records were not remarkable. The author hopes that kites will be used on steamers which would create sufficient wind even in calms, especially in the tropics, where we have no observatories, and for the exploration of the trade winds. He quotes Hildebrandson in his support, who would fit the steamers also with balloons. H. B.

439. *Mean and Normal Meteorological Values.* **E. v. Rijckevorsel.** (Archives Néerlandaises, 6. pp. 367–370, 1901.)—The author shows that it would hardly be possible to obtain normal meteorological values directly by taking means, even if we had statistics covering thousands of years at our disposal. For exemplification of this he gives series of temperature, barometer, and sun-spot observations for periods of various lengths, 31, 30, 20, 10, 5 days. H. B.

440. *Transparency of the Air from Observations of Distant Objects.* **E. Oddone.** (N. Cimento, 5. pp. 264–268, Oct., 1901. Rend. del R. Ist. Lomb. di Sc. e Lett, Ser. 2, 34, p. 24, 1901.)—Previous observations have been made either for distances of a few metres or for the height of the atmosphere. The author has endeavoured to fill the gap. His method was to compare (indirectly) the brightness of the snow on distant Alpine peaks with that of snow near at hand, each being directly compared with a white metal plate. He chose times when the peaks appeared nearly identical in brightness with the background of sky against which they were seen, a precaution necessary in order to obtain a sufficiently large field of view in the photometer (a Bouguer photometer, with blackened draw-tubes, adjustable in altitude and azimuth). When there was doubt as to the actual visibility of the peak, this was tested by employing a Nichol prism to cut off the polarised light of the sky, and thus allow the peak to show up by contrast. Lambert's law of illumination was assumed in calculating the results. The following values were obtained for the mean coefficient of transmission per km.:—

Date.	Snow Peak Observed.	Distance in km.	Coefficient.
Feb. 14 and 16	Monte Penice ....(1462^m)	45	$0{\cdot}95_5$
Jan. 1, March 4.........	M. Grigna, north ...(2410^m)	85	$0{\cdot}98_8$
March 4	M. Weissmies ....(4031^m)	134	$0{\cdot}99_5$

A. E.

441. *Antisolar Coronas at the Pûy de Dome.* **B. Brunhes.** (Comptes Rendus, 133. pp. 1204–1207, Dec. 23, 1901.)—Since October 2, 1901, four observations of antisolar coronas (Spectre of the Brocken) have been made by the author, and twenty by David at the observatory on the summit of the Pûy de Dome. The greatest number of rings seen was four, and the usual number three. The outer edge of each ring is red, and the inner generally green, except the inner part of the ring of least diameter, which is yellow. The internal and external diameters of the first and second rings were repeatedly measured, and exhibited considerable variations; these variations are shown to depend on the humidity of the air, the diameters of the rings decreasing with increase of moisture in the air, and therefore with increase in size of the drops of water which are the cause of these phenomena.

W. C. B.

442. *Two-foot Yerkes Reflecting Telescope.* **G. W. Ritchey.** (Astrophys. Journ. 14. pp. 217–233, Nov., 1901.)—The article contains a description of improvements adopted in the installation of the new reflector at the Yerkes Observatory, complete details as to subsidiary equipment for general and special investigations, and also a special design suggested for a proposed new reflector of 5 feet aperture. The performance of the 2-foot instrument is shown by two excellent reproductions from photographs of nebulæ. C. P. B.

443. *Solar Constant.* **F. W. Very.** (Monthly Weather Rev. 29. pp. 357–366, 1901.)—The author first summarises the difficulties involved in the determination of this important factor, the majority being due to the indirect methods of observation which are of necessity followed. In the choice of instruments as simple arrangements as possible should be employed, as the theory of many of the complicated methods in present use is far from being definite. Passing over comparative descriptions of the chemical actinometer used by Vallot and of Paschen's repeating bolometer (specially commended as accurate for spectral energy work), it is suggested that the first investigation going really to the root of the matter was that of Langley at Mount Whitney, by making a bolometric determination of the entire infra-red spectrum. This work leads directly to the important distinction between the two different kinds of selective depletion in operation, whereby the solar rays suffer in traversing the earth's atmosphere. Numerous references to the work of subsequent investigators are next given and discussed, the main cause of discrepancy appearing to arise from inadequate formulæ of reduction. The absorption must be separately allowed for under the two forms—(*a*) *band absorption*, chiefly taking place in the upper air at the longer wave-lengths, is quite local in its action, and including the greater part of the infra-red absorption of water-vapour; (*b*) *selective reflection*, which acts chiefly in the lower atmosphere at short wave-lengths. The low layers of a moist atmosphere become heated because they absorb the rays of extremely long wave-lengths emitted by the heated soil. On these considerations the author states that most of the past reductions of actinometric measurements do not give the solar constant, but this quantity diminished by the band absorption which has escaped detection. A new reduction of the Mount Whitney observations gives the comparatively high value of 3·127 for the solar constant. [See further Abstract No. 344 (1901).] C. P. B.

444. *Variability of Earthshine.* **H. H. Kimball.** (Monthly Weather Rev. 29. pp. 209–211, 1901. Paper read before the Astronomical and Physical Society of Toronto, 1901.)—The author develops Bond's formula for reflected light by introducing terms representing the albedos of the earth and moon and the distance between these two bodies. In the observation of earthshine, which is due to the light reflected from the earth's surface, the chief factors are the distance and the albedo of the earth. The main causes of variation in the latter are: (1) The distribution of land and water surfaces on the hemisphere illuminated by the sun; (2) the extent of the hemisphere enveloped in clouds; (3) the variation in character of the cloudy area, and the presence or absence of snow.

Bond, Herschel, and Zöllner have measured the relative albedos of various rock surfaces, water, &c., compared with white paper at various angles of incidence. In the case of the other factor, the variation in distance from 221,000 miles at perigee to 253,000 miles at apogee may introduce as much as 50 per cent. alteration in the intensity of the earthshine, and it is concluded that the variation observed is mainly due to this factor. C. P. B.

445. *The Annular Eclipse of the Sun on November* 10, 1901. **A. de la Baume-Pluvinel.** (Comptes Rendus, 133. pp. 1180–1185, Dec. 23, 1901.)—A series of visual and photographic observations of the eclipse carried out in Cairo under very fair atmospheric conditions. Before and after the annular phase several photographs of the sun's spectrum close to the moon's disc were taken, the edge of the moon being tangential to the slit. These photographs were examined very carefully, and showed no trace of any change in the Fraunhofer lines close to the moon's edge, which is a further proof of the non-existence of a lunar atmosphere. This was also borne out by visual observation of the spectrum between D and *a*.

A photograph was also taken of the spectrum of the crescent of the chromosphere which appears just before the second contact. This shows 49 rays whose wave-lengths are given, and of these 14 have not been before observed. Amongst the remainder those due to hydrogen and the H and K calcium lines are very intense.

Another photograph was taken, immediately after the second contact, of the spectrum of the narrow segment of the sun's surface. It was found that the hydrogen lines were quite absent—a fact which the author explains by considering that the bright hydrogen spectrum of the chromosphere balances the effect of the absorption due to the photosphere. This, however, is not the case with the H and K calcium lines. Photographs taken of the sun in the middle of the eclipse showed no trace of the corona.

A laudatory note on the above is added by J. Janssen. E. C. C. B.

446. *Temperature and Composition of Planetary Atmospheres.* **E. Rogovsky.** (Astrophys. Journ. 14. pp. 234–260, Nov., 1901. Revised and translated by the author from Transactions of the Russian Astronomical Society, Part 7, pp. 10–34, 1898, and Part 8, pp. 32–45, 1899.)—The paper contains an analysis of the results obtained by various methods involving different laws of radiation. Tables are given showing the probable relative temperatures and composition of the several planetary surroundings. The author concludes that the physical and chemical constitutions of the atmospheres of all the members of the solar system are in close relation, and that any variations in that of the central sun produce corresponding changes in the others, although a considerable interval may intervene between the two changes. C. P. B.

447. *Spectrum of Nova Persei.* **W. W. Campbell, W. H. Wright,** and **J. Stebbins.** (Astrophys. Journ. 14. pp. 269–293, Nov., 1901. From the Lick Observatory Bulletin, No. 8.)—The paper contains a complete account of the changes observed in the spectrum of Nova Persei as determined from photographs obtained at the Lick Observatory. Six plates of reproductions of the spectra at various stages are included, and tables of the measured wave-lengths of the lines found on the photographs. C. P. B.

448. *Changes in the Nebulosity around Nova Persei.* **G. W. Ritchey.** (Astrophys. Journ. 14. pp. 293–294, Nov., 1901.)—Photographs obtained with a 2-foot silver-on-glass reflector at the Yerkes Observatory showed distinct evidences of changes in the form of many of the principal condensations in the nebulosity surrounding the new star in Perseus. Exposures varying from one to seven hours were given, and the plates carefully measured. Four of these photographs are reproduced, and the changes described are clearly visible. It is not yet known whether these changes are due to an actual translatory motion of some definite portion of matter, or whether successive portions of an extensive area of nebulous matter are rendered luminous by disturbances at different times. C. P. B.

REFERENCE.

449. *Cavendish Apparatus.* **M. Kohl.** (Ann. d. Physik, 6. 3. pp. 641–645, Nov., 1901.)—A convenient and transportable form of apparatus is described for Cavendish's experiment on the mutual gravitation of two masses. A. D.

LIGHT.

450. *New Form of Radiometer.* **F. A. Saunders.** (Astrophys. Journ. 14. pp. 136–137, 1901.)—The author describes a new form of case for the radiometer described by E. F. Nichols (Wiedemann's Annalen, 60, 401, 1897). The advantages of the present form are as follows: The apparatus is practically airtight, requiring exhaustion only about once a month. Tinfoil strips in connection with the case project into the interior and dissipate any electric charges in an hour or two after exhaustion. The system may be turned about a vertical axis without altering the pressure within the tube, and so the zero-point may be adjusted. Finally, the instrument is very sensitive, cheap, and easy of adjustment. W. S.

451. *Determination of Crystalline Systems of Microscopical Crystals.* **J. L. C. Schroeder van der Kolk.** (Archives Néerlandaises, 4. pp. 341–345, 1901. Translated from Zeitschr. f. Wiss. Mikrosk. 12. pp. 188–192, 1895.)—Certain practical difficulties are met with in the above determination by means of the polarising microscope, *e.g.*, it is not always possible to distinguish between uniaxial and biaxial crystalline needles. By means of a hemisphere of glass whose convex side is introduced into the circular opening of the microscope table, and whose plane side serves to hold the object, the following motions of the crystalline needle are attained: (1) Round its axis, (2) round the horizontal normal to the axis, (3) round these two in succession, (4) round the vertical. By these means, it is possible to distinguish several cases that would be otherwise ambiguous or difficult. Illustrations are given for several systems. J. W. P.

452. *Reflecting Power of Metals for Ultra-Violet Rays.* **E. Hagen** and **H. Rubens.** (Deutsch. Phys. Gesell., Verh. 3. 13. pp. 165–176, 1901. Communicated by the Physikalisch-Technischen Reichsanstalt.)—The rays are examined by means of a linear thermo-couple which replaces the eyepiece of a spectrometer. The source of the ray is the positive crater of an arc lamp. Besides the already known bands in the ultra-violet, the authors found three others with intensity maxima of wave-lengths 305, 288, and 251 μμ respectively. The rays are filtered through water, and focussed by quartz lenses on to a right-angled quartz prism, placed near the centre of curvature of the concave metal mirror examined. By use of the prism in two positions the rays can be reflected either to the mirror on one side or in the opposite direction through an achromatic combination which focusses them, or the rays from the mirror, on the slit of the spectrometer. The rays are thus examined before and after reflection. No glass is employed in the construction of the apparatus, except for a filter screen. The relative reflecting powers for wave-lengths varying from 500 to 251 μμ were measured, the numbers being reduced by means of values previously found [see Abstracts Nos. 992 (1899) and 463 (1900)] by an optical method. The numbers obtained for silver and gold by the two methods respectively are in good agreement. Nutting's results [see Abstract No. 285 (1902)] agree only approximately with those of the authors, and for silver alone. His method is considered unsuitable for quantitative measurements. The reflecting powers are in percentages of the incident radiation.

For λ =	251	288	305	316	326	338	357	385	420	450μμ
Fresh silver	34·1	21·2	9·1	4·2	14·6	55·5	74·5	81·4	86·6	(90·6) 90·4
Old silver	19·2	15·9	12·3	5·6	8·8	45·0	61·0	71·0	79·9	88·7
Platinum	33·8	38·8	39·8	—	41·4	—	43·4	45·4	51·8	(55·8) 54·2
Nickel	37·8	42·7	44·2	—	45·2	46·5	48·8	49·6	56·6	(58·5) 59·8
Steel (unhardened)	32·1	37·1	41·1	—	41·1	41·9	43·1	44·0	51·0	(56·3) 52·5
Gold	38·8	34·0	31·8	—	28·6	—	27·9	27·1	29·3	(36·8) 31·3
Copper	31·5	29·7	30·9	—	30·4	—	33·3	34·9	39·9	(48·8) 45·2
Rosse's alloy	29·9	37·7	41·7	—	—	—	51·0	53·1	56·4	(62·9) 58·5
Schroeder's alloy No. 1	40·1	48·4	49·8	—	54·3	—	56·6	60·0	62·2	(62·4) 62·7
Schroeder's alloy No. 6	39·2	42·7	44·7	—	50·1	—	53·0	55·3	59·6	(61·5) 60·4
Mach's magnalium 69 per cent. Al + 31 Mg	67·0	70·6	72·2	—	75·5	—	81·2	83·9	83·3	(83·4) 83·4
Brandes-Schünemann alloy	35·8	37·1	37·2	—	39·3	—	43·3	44·3	47·2	(49·1) 49·2

The numbers in brackets were found by the optical method. G. E. A.

453. *Photographed Gratings.* **G. Meslin.** (Journ. de Physique, 8. pp. 750–751, Dec., 1901.)—The author has succeeded in making gratings by photographing, on a bichromated gelatine plate, the bands produced by a narrow slit and a grating. The sensitive plate was placed in a small dark chamber fitted with a camera shutter, being developed, after several minutes' exposure, in tepid water. The photographs have been reproduced in other journals. G. E. A.

454. *Anomalous Dispersion of Sodium Vapour.* **R. W. Wood.** (Roy. Soc., Proc. 69. pp. 157–171, Dec. 24, 1901.)—An accurate study of the dispersion of a substance with absorption bands so narrow and strong as those of sodium vapour, should be of great value in testing the various dispersion formulæ. The author has, therefore, made experiments to determine whether sufficient data could be obtained. He has succeeded in forming a complete anomalous spectrum in which all the colours are present, except a range of some 20 Ångström units at the D lines. The first experiments were made with a large hollow prism of iron with glass windows. Great trouble was experienced from deposits on the glass, and as it was evident that the oblique faces played but a small part, the refraction being due almost wholly to the variation of density in the vapour, the prism form was given up, and a tube, preferably of sheet iron, about 80 cm. long, and 2 cm. wide, was adopted instead, having plate-glass ends, attached with sealing-wax, at such a distance from the heated vapour that no deposit occurred. Dry hydrogen is conducted into and out of the tube by two glass tubes passing through the wax. A piece of sodium having been inserted, the tube, placed horizontally, is heated by a Bunsen burner. In order to study the dispersion of the vapour, the light of an arc lamp is focussed on the *horizontal* slit of a collimator, and the parallel rays from the latter pass lengthwise through the dispersion tube. A second lens brings them to a focus on the *vertical* slit of a spectroscope or, when desired, in the focal plane of an eyepiece. With the latter a superb spectrum is seen. A thin thread of violet occupies the centre. Next it is a wide dark band, due to the D absorption. Then comes a flare of red, fading off to orange. On the other side of the violet is blue, then a gap, corresponding to the fluted spectrum below, then a flare of green ranging on to yellow.

On spectroscopic examination, with the crossed slits above described, the spectrum appears as two oppositely curved branches, one on each side of D. The breadth of the D absorption band is sometimes 15 times the distance of the D lines. As the tube grows hotter, both branches grow out rapidly, and a beautiful fluted absorption appears in the red and greenish-blue, which finally blots out a region in the blue. Meanwhile the curvature increases remarkably, and the entire red end is lifted high above the blue end. In consequence of the rapid changes, the following method was adopted in measuring deviation: The telescope of the spectrometer was replaced by an objective of 2 m. focus, in whose focal plane a glass plate was mounted, with an eyepiece behind it. Positions could then be recorded by scratching on the glass. By making the dispersion tube the chamber of a radiophone, the author proved that much of the energy absorbed by the sodium vapour is spent in raising its temperature. The question is raised whether there is any lateral emission of light by sodium ions in resonant vibration. A way is described of producing a very satisfactory prismatic sodium flame by passing hydrogen through a tube containing strongly heated metallic sodium, and burning the gas at a flat jet piece made of platinum foil. Reproductions of photographic spectra are given, and also a striking coloured picture of the anomalous spectrum, as viewed directly. A. E.

455. *Anomalous Dispersion of Oxyhæmoglobin.* **L. Puccianti.** (N. Cimento, 5. pp. 257–264, Oct., 1901. From a paper read before the Società Italiana di Fisica, Bologna, Sept. 24, 1901.)—The absorption spectrum of oxyhæmoglobin presents two characteristic bands; one α, between yellow and green, extending from 0·589 μ to 0·570 μ, the other β between green and blue-green, extending from 0·550 μ to 0·530 μ. These bands are visible, even with a fairly thin layer of very dilute solution. The crossed prisms method being found not sufficiently sensitive, an interference method was adopted; Jamin's refractometer being used in conjunction with a spectrometer. The rays from the sun or an arc lamp, collected by a lens, fall at 45° on a thick glass plate. The reflected rays, after passing through the trough and a compensator, are again reflected at 45° by a second thick plate parallel to the first. Interference fringes are thus produced, of which a real image is formed on the slit of the spectrometer by means of an achromatic lens. The trough is divided transversely, one portion containing the solution, the other water. Rays reflected from the front of the first plate pass through one half, from the back through the other half. The field of the spectrometer is crossed by a series of alternate dark lines and narrow spectra, corresponding to the dark and bright interference bands. The spectra are sharpest in the red, and most diffuse in the absorption regions, the diffuseness increasing with the strength of the solution. Initially, the central dark line is brought to coincidence with a horizontal reference wire. As the strength of the solution is gradually increased, the bands are displaced, the whole series assuming an upward slant from red to violet, except in the two regions corresponding to the α and β absorption bands, where the slant is much less, or even reversed. If m be the number of black bands seen crossing the horizontal wire, then $r = m\lambda$ gives the retardation. The index n is then obtained from the formula $n = 1 + r/ns$, n being the refractive index of water relative to air, and s the distance traversed in the solution. Curves are given showing the variation of retardation with wave-length for different concentrations. The drop at each absorption band, and rapid rise on approaching it, are very obvious. Commercial hæmoglobin was used in most of the experiments. A. E.

456. *Reversible Actions of Light.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 3. 14. pp. 182–188, 1901.)—The colours produced in glass by kathode rays are destroyed by ultra-violet light or by sunlight. The changes produced by ultra-violet light are reversed by waves of greater length. The colours can also be destroyed by heating. Silver chloride, enclosed in a tube and darkened by sunlight, will, in the dark, take up the liberated chlorine again and resume its original colour. In continuous light a condition of equilibrium is reached, the pressure of dissociated chlorine depending upon the brightness of the light. Bromide of silver blackened by kathode rays put in a closed tube (16 to 18 mm. wide) in the sunshine becomes in three-quarters of an hour of its original colour all through, except at the illuminated surface; in diffused light this result is reached in about two days (with AgCl some months are required). Bromide of silver prepared by dissolving AgCl in ammonia and adding KBr and HNO_3 is readily powdered; and if the ammonium nitrate have not been quite washed out of it, it is comparatively very insensitive to light, taking hours or days, instead of seconds, to darken, but is promptly darkened by kathode rays. If, however, the blackened powder is tilted in the tube out of the way of the kathode rays, the positive light of the discharge will regenerate it in a fraction of a minute; and, again, if the vacuum be varied so as to make the kathode discharge luminous, the blackening is immediately destroyed. Iodide of silver blackens and liberates iodine under kathode rays; a few days' daylight regenerates the yellow iodide; a few seconds under the positive light of the discharge will do the same if the blackened iodide be warmed. A. D.

457. *Induced Radio-activity.* **P. Curie** and **A. Debierne.** (Comptes Rendus, 133. pp. 931–934, Dec. 2, 1901.)—Various solid bodies acquire induced radio-activity when placed in a closed vessel with a radio-active salt of radium. The effects obtained are more regular and more intense when the radium salt is in the form of an aqueous solution. The induced radio-activity is independent of the pressure, and of the nature of the gas in the enclosure. Certain substances, those becoming phosphorescent on exposure to light, and certain others, become luminous when placed in an activating enclosure. If two glass globes be arranged, communicating by a bent tube, and in one a solution of an active barium salt containing a few milligrammes of radium, be put, and in the other a substance such as sulphide of zinc, the zinc sulphide becomes brightly luminous, as much so as when it has just been exposed to an intense light. The luminosity is due to the induced radio-activity communicated through the bent tube, and not to direct radiation from the radium. The intensity of the Becquerel radiation from the zinc sulphide in this experiment is exactly the same as that from a piece of copper or any other substance placed in the same conditions. The glass also becomes phosphorescent by induced radio-activity. The induced radio-activity of bodies placed in an activating enclosure depends essentially on the free space existing around them. An activating enclosure of glass is illuminated

entirely, but not equally throughout, the wider portions of the tube being more luminous and more radio-active. The final activity in an enclosure when the limiting value has been reached, perhaps after some weeks, depends only on the quantity of radium which has been introduced in the state of solution, but in a wide enclosure the active state is reached more rapidly. The activity increases in an enclosure when the quantity of activating solution is increased. The power of activation of a solution is thus not analogous to a vapour tension. J. J. S.

458. *Influence of Radio-active Substances on the Luminescence of Gases.* **A. de Hemptinne.** (Comptes Rendus, 133. pp. 934–935, Dec. 2, 1901.)—The author has already shown that a gas which becomes luminous at a certain pressure, under the influence of electric vibrations, becomes luminous at a higher pressure, when it is submitted at the same time to the action of Röntgen rays. He now finds that if radio-active substances are brought near a tube containing air at feeble pressure, and exposed to electric vibrations, the air becomes luminous at the pressure of 44 mm., whilst without the substance the pressure must be diminished to 33 mm. in order to observe the luminescence. The luminosity, which was reddish-violet in the last case, was yellowish-green under the influence of the radio-active substances. Above a large metal plate, which was the seat of Tesla vibrations, a large tube, 1 m. long and 8 cm. in diameter, was suspended horizontally by silk threads; the tube contained air at a pressure of about 10 m. When the tube was brought sufficiently near the plate it became luminous; when moved to a distance the light became feeble, and was finally extinguished. If a radio-active substance were then brought near the tube, yellowish glimmers were given out in the neighbourhood, their extent depending on the distance between the large tube and the plate; when the radio-active substance was displaced along the tube, the glimmering light displaced itself with it. J. J. S.

459. *Chemical Action of Radium.* **Berthelot.** (Comptes Rendus, 133. pp. 973–976, Dec. 9, 1901.)—Experiments were made to determine whether radium exerted any decomposing action on iodine pentoxide, this reaction being chosen on account of its endothermic character. The radio-active material had a mass of 0·145 gr., about one-eighth of this being chloride of radium, and the remainder chloride of barium. It was placed in a very small sealed glass tube which was surrounded by a thin, somewhat wider, tube, around which was placed 4 to 5 grammes of white iodine pentoxide, any volatile products of decomposition being carried off by a current of dry air. The decomposition of the iodine pentoxide was noticed only under the influence of radium, and when the tube containing it was not surrounded by black paper, that is, under the conditions in which the phosphorescence of the mixture manifests itself. The radiations which produce this phosphorescence in consequence of a double transformation of energy played a characteristic part in the actual experiment. Series of experiments were carried out at 10° and at 100°. According to Curie and Becquerel, the energy radiated by a layer of radio-active matter of 2 mm. thickness spread over 1 sq. cm. of surface is about 5 c.g.s. units of energy per second. Calculating from these numbers the amount of iodine set free by the endothermic decomposition of I_2O_5 in the experiment described would amount to not more than $\frac{1}{100}$ of a milligramme. This value corresponds to the order of magnitude of the phenomena observed by the author. J. J. S,

460. *The Radio-activity of Uranium.* **H. Becquerel.** (Comptes Rendus, 133. pp. 977–980, Dec. 9, 1901.)—When in solutions of chloride of uranium containing a little barium chloride, the barium is precipitated in the form of sulphate, the precipitate carries down with itself an active product. The precipitate is not only strongly radio-active, but, according to the proportions of uranium and barium, it may become notably more active than uranium. At the same time the salt of uranium taken from the liquid has become less active. After eighteen successive operations of this sort the author formerly obtained a uranium salt of little activity. The progressive enfeeblement of the products thus got was shown in various ways, *e.g.*, by the action on an electrometer and on a photographic plate. The question arose whether uranium salts which had partially lost their radio-activity regained it after lapse of time; and on examining after eighteen months the progressively enfeebled products which had been prepared it was found that they were almost identical, and that they had spontaneously regained the activity which they had lost. On the other hand, the precipitated barium sulphate was found to have become completely inactive. The loss of activity shows that the barium does not take away the essentially active and permanent part of uranium. There appears to exist an activity peculiar to uranium, although it is not shown that this metal is not intimately joined to another very active product, not separated by the operations described.

The author suggests a hypothesis which is not in disagreement with most of the facts observed. If the emission of the deviable rays, identical with the kathode rays, is the cause of the emission of the non-deviable radiation, which would then be analogous to the Röntgen rays, this spontaneous emission being comparable with the evaporation from an odoriferous body, radio-activity would resemble a known phenomenon. The energy dissipated would be furnished by the active body itself, but the corresponding loss of weight would be too feeble to be observed. In accordance with a hypothesis of J. J. Thomson there would be two kinds of particles of different sizes, the one kind about a thousand times smaller than the other; on separating, the smaller would carry negative charges, and would attain enormous velocities, which would permit their passage through bodies; the others, larger, whose masses would be of the order of those of the electrolytic ions, would possess much smaller velocities; they would, therefore, not pass through bodies, and would behave somewhat like a gas, forming on all bodies, excepting those electrified positively, a material deposit, which would explain the phenomena of induced radio-activity, and the identity of the induction on different solids, whatever their nature. This deposit of matter would be capable of dividing itself in its turn into smaller particles which could pass through glass, giving the rays, deviable and non-deviable, observed with induced substances, and it would be in consequence of this molecular subdivision that induced radio-activity would dissipate itself, even across an envelope of glass. This phenomenon of the setting at liberty of the ions from a part of the molecules in solutions might account for the increase of the inducing power of certain active bodies when they are dissolved. The emanation which produces radio-activity must not, however, be considered as similar to an ordinary gas, for, according to the experiments of Curie, the equilibrium which is established in an enclosure between the active matter and the induced walls is a function of the quantity of active matter, and there is no phenomenon analogous to the maximum tension of a vapour.

In conclusion, the author confirms his previous observation that the radiation from uranium is not modified at the low temperature of liquid air. [See also Abstract No. 2166 (1900).] J. J. S.

461. *Chemical Action of Kathode Rays.* **G. C. Schmidt.** (Phys. Zeitschr. 3. pp. 114–115, Dec. 15, 1901.)—In explanation of the decomposition of compounds sensitive to light by kathode rays, Goldstein (Wied. Ann., 1880, p. 832) put forward the hypothesis that a thin layer of ultra-violet light appears at the point where the body is struck by the kathode rays. In the light of our present conception of the kathode rays as consisting of rapidly moving, negatively charged particles, the so-called electrons, this action may, however, be regarded in another way. When, for example, the rays impinge on a salt, like silver chloride, consisting of a positively charged silver atom and a negatively charged chlorine atom, the electron can only be permanently retained by the salt if it satisfies one of the valencies of the silver; the latter will, therefore, not be capable of combining with so much chlorine as before, so that one chlorine atom will be evolved in combination either with a positively charged electron, or with another chlorine atom forming an indifferent chlorine molecule, whilst silver subchloride remains. According to this view all compounds containing volatile acid radicles will be reduced by kathode rays. The number of compounds which can be submitted to this test is, however, small, since owing to the fact that only the exterior layers undergo decomposition by the kathode rays, it is necessary that the chemical reactions employed should be extremely sharp. Such decomposition has been detected in the cases of ferric, mercuric and silver chlorides, which are reduced to lower chlorides; for the last-named compound the composition of the product of the action of the kathode rays was determined by measuring its potential relative to N/10 hydrochloric acid, the value found differing by less than 0·001 volt from that of Ag_2Cl. In addition to the evidence already brought forward by Wiedemann and the author [see Abstract No. 401 (1898)] in support of the view that the coloration produced in alkali kaloid salts is due to the formation of subchlorides or bromides, it is now found that, when potassium chloride is so acted upon, it yields an alkaline aqueous solution.
T. H. P.

REFERENCES.

462. *Action of Light on Metallic Surfaces.* **H. Buisson.** (Annal. Chim. Phys. 24. pp. 320–398, Nov., 1901.)—A paper on the same lines as, but more complete than, the one referred to in Abstract No. 24 (1902).
A. D.

463. *Colour Photography.* **W. de W. Abney.** (Soc. Chem. Ind., Journ. 20. pp. 1060–1071, Nov., 1901.)—The paper treats very fully of the colour sensation and luminosity curves of the spectrum, and explains their application to three-colour photography by Ives', Joly's, and Sanger-Shepherd's methods. Some mention also is made of colour printing in opaque inks. [See also Abstract No. 812 (1900).]
G. H. B.

464. *Flying Shadows.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 3. 14. pp. 189–190, 1901.)—This paper contains a description of flying shadows, analogous to those traversing the landscape upon a total eclipse of the sun, seen under a searchlight.
A. D.

465. *Magnetic Rotation of the Plane of Polarisation in an Absorption Band.* **W. Voigt.** (Ann. d. Physik, 6. 4. pp. 784–793, Dec., 1901.)—A mathematical discussion of the theory of this magneto-optical phenomenon with special reference to the experiments of O. M. Corbino.
E. H. B.

HEAT.

466. *Petroleum-Ether Thermometers.* **L. Baudin.** (Comptes Rendus, 133. p. 1207, Dec. 23, 1901.)—The author uses, for low temperature work, a petroleum-ether of specific gravity 0·647 at 15° C., which is of lower density than that used by Kohlrausch. This works well, as the ether remains liquid, and quite transparent, at the boiling-point of liquid oxygen.

W. C. B.

467. *Photometric Pyrometer.* **H. Wanner.** (Phys. Zeitschr. 3. pp. 112–114, Dec. 15, 1901.)—The author has designed an apparatus, suitable for practical work, for the measurement of temperature by photometry of monochromatic light issuing from the body whose temperature is to be measured. The principal use of a pyrometer is in measuring the temperature of ovens, and these, in common with all hollow bodies, give practically "black" radiation. Wien's formula is, therefore, generally applicable. The apparatus consists of a direct-vision spectral-photometer, with twin prisms giving monochromatic light of wave-length 0·6563μ. The comparison light is a 6-volt incandescent lamp, which is standardised against an amyl-acetate lamp. The two illuminations are brought to equal intensity by rotating the eyepiece nicol, which is provided with a scale of degrees. The range of the instrument is from 900° C. to 2,000° C., and this can be further increased by interposing a light-absorbing medium in the path of the radiation from the hot body. To test the accuracy, the author used the instrument to increase the temperature of a "black body" containing a standardised thermo-element. In the measurements, taken on different days, the maximum error was ¾ of 1 per cent.

G. H. B.

468. *Production of Low Temperatures.* **d'Arsonval.** (Comptes Rendus, 133. pp. 980–983, Dec. 9, 1901.)—The author gives some notes on the practical details of the methods for producing and maintaining low temperatures. To obtain a temperature of —60°, methyl chloride may be employed, which should be put in a porous vessel. Thus the spontaneous evaporation avoids the necessity of blowing into the liquid. To descend to —112° or —115°, carbonic acid or acetylene may be used. The best solvent for these in the state of snow is acetone. For temperatures below —115°, liquid air must be used, to obtain which conveniently the author recommends the Linde apparatus. In conclusion he gives details of the manipulation employed for maintaining constant the low temperatures produced by liquid air.

J. J. S.

469. *Coefficient of Expansion of Concrete.* **W. D. Pence.** (West. Soc. Engin., Journ. 6. pp. 549–559; Discussion, pp. 559–575, Dec., 1901.)—The author describes an elaborate series of tests carried out in the School of Civil Engineering of Purdue University. Concrete bars were made according to a standard specification described by E. Thacher. The length of the bars in the final tests was 36 inches by 4 inches diameter, the section being cylindrical. They were heated in a steam jacket, and the measurements were made by means of an optical lever. The mean results give the value 0·0000055 per degree Fahrenheit.

W. W. H. G.

470. *Specific Heat of Tungsten and of Molybdenum.* **E. Defacqz** and **M. Guichard.** (Annal. Chim. Phys. 24. pp. 139–144, 1901.)—The authors employed a Berthelot calorimeter. Two specimens of tungsten were employed, containing respectively 99·81 and 99·87 per cent. of the metal. For tungsten they find the mean specific heat to be as follows: Between 15° C. and 93° C., 0·0340; between 15° and 258°, 0·0366; between 15° and 423°, 0·0375. From those values they deduce the specific heat at t° C., obtaining the value $C_t = 10^{-10}(313{,}903{,}582{\cdot}57 + 516{,}282{\cdot}0216t - 933{\cdot}0108t^2)$. This result is somewhat higher than that of Regnault, who did not give the composition of the metal which he used. The specimen of molybdenum used contained 99·78 per cent. of the metal. For this metal the mean specific heat was determined for various ranges of temperature, the lowest being from 15° C. to 85° C., the greatest from 15° to 444°. The constant value 0·073 was found for the specific heat, which is again slightly above that obtained by Regnault. W. S.

471. *The Theoretical Evaluation of* γ. **J. H. Jeans.** (Phil. Mag. 2. pp. 638–651, Dec., 1901.)—A gas consists of molecules each having n degrees of freedom, including three of translation. If E be the mean value of the energy of translation [which the author does not define], E + F the whole mean kinetic energy, and if, in stationary motion, $F = f(E)$, then—

$$\gamma = 1 + \frac{2}{3\{1 + f'(E)\}}, \text{ where } f'(E) = \frac{d}{dE} f(E).$$

If Boltzmann's assumptions are now made—

$$f(E) = \frac{n-3}{3} E, \text{ whence } \gamma = 1 + \frac{2}{n}.$$

This result, being impossible for polyatomic molecules, must be got rid of if not *à priori* by rejecting the assumption, then *à posteriori* by introducing a new agent; this new agent is ether, as in former papers by the same writer. And it gives great freedom of hypothesis. Ether is here introduced as a vehicle for correspondence by which energy is interchanged between molecules, not as itself possessing energy. To begin with, there is assumed to be no dissipation, all the energy entrusted to ether by a molecule being absorbed by other molecules. In the stationary state E_0, F_0, are the values of E, F and $F_0 = f(E_0)$. Then, generally, $\frac{dF}{dt} = \chi(E_0)\{F - f(E)\}$, where χ denotes some function. It is then assumed that E and F will oscillate about, and not depart widely from, their mean values, conditions which are expressed by the equations

$$E = E_0 + E_1 \epsilon^{ipt}, \qquad F = F_0 + F_1 \epsilon^{ipt},$$

and if ρ denote density [which is not defined], and π denote pressure, connected with E and ρ by the formula $\pi = \lambda E \rho$ (λ being constant) then also—

$$\pi = \pi_0 + \pi_1 \epsilon^{ipt}, \text{ and } \rho_0 = \rho_1 + \rho \epsilon^{ipt}.$$

From these data the author deduces—

$$\Gamma = 1 + \tfrac{2}{3}/\{1 + f'(E)\}\left(1 + \frac{ip}{\chi(E)}\right),$$

which is thus a generalised form of γ, which, when p is infinite, reduces to $1\frac{2}{3}$. The best method of determining γ is by its relation to the velocity of sound. Generally, if a be the Newtonian velocity, the actual velocity is $a\sqrt{\Gamma}$. The author explains the relation between the value of γ, as determined by the velocity of sound, and its true value. So long as $p/\chi(E)$ is inappreciable the difference is small, but increases as p increases.

As an illustration of the theory, the lag in rotatory motion of air is considered, the molecules being rigid bodies having two degrees of freedom of rotation. The author then again introduces the conception, which we owe to him, of subsidiary degrees of freedom. They are those for which the transfer of energy depends as much on ether interactions as on encounters. If a molecule has $n + 3$ principal, and m subsidiary degrees, he finds that—

$$\frac{\Gamma-1}{2} = \{n + 3 + 3mf'(E)\}\left(1 + \frac{ip}{\chi(E)}\right)$$

At low temperatures γ approximates to the classic form $1 + \frac{2}{n+3}$, but increases with increasing temperature.

The conclusions are :—

(1) If there be no energy but that of translation $\gamma = 1\frac{2}{3}$. (2) If γ differs from $1\frac{2}{3}$, it is generally a function of the temperature. (3) Its general value is $1 + \frac{2}{n + 3 + 3\Sigma f'(E)}$, the summation Σ including all subsidiary degrees of freedom. Also $f(E)$ is very small at normal temperatures. As the temperature rises, more pairs of molecules approach each other sufficiently near to affect sensibly their internal vibrations. S. H. B.

472. *Heat Radiated from a Wire in Vacuo.* **R. Kempf-Hartmann.** (Phys. Zeitschr. 3. pp. 109–110, Dec. 15, 1901.)—A platinum wire was stretched in a long glass tube, and from its centre was hung a small weight, serving as an index of the extension of the wire ; a side tube contained this weight and a small scale. The author measured the current, the sinking of the weight, and the times required to reach a constant deflection and to return to zero, at different degrees of vacuum. The sensitiveness of the arrangement increased very largely with the degree of vacuum. The value of the square of the current divided by the deflection was, at a kathode-ray vacuum, 0·000085, and at 6 or more cm. of mercury, 0·011. The time required to reach a constant deflection increased with the degree of vacuum.

G. H. B.

REFERENCES.

473. *Correction for Expansion of Thermometer Scales.* **H. F. Wiebe.** (Archives Néerlandaises, 6. pp. 323–332, 1901.)—In general, thermometers are made of the same kind of glass throughout, bulb, tube, and scale ; but in certain standard thermometers the scale is of material different to the bulb and tube. The author investigates the correction to be applied in the use of these instruments. R. A.

474. *Isothermals of Hydrogen.* **E. H. Amagat.** (Phil. Mag. 2. pp. 651–653, Dec., 1901.)—This is a correction of a statement by Rose-Innes that the isothermals of hydrogen as experimentally determined by Amagat are a set of parallel straight lines. [See Abstract No. 2126 (1901).] R. E. B.

475. *Meniscus Changes of Saturated Vapours.* **V. Blaess.** (Phys. Zeitschr. 3. pp. 115–117, Dec. 15, 1901.)—The author gives a graphic method by which the change in volume of a liquid corresponding with any given change in its state can be determined. T. H. P.

SOUND.

476. *Interference Phenomena.* **D. van Gulik.** (Archives Néerlandaises, 6. pp. 287–298, 1901.)—The author observes that in the noise emitted by the steam escaping from the safety valve of a locomotive on the point of starting, definite and different pitches may be noticed, provided the observer takes up certain positions on the platform of the station. The phenomenon is traced to the reflecting action of the platform, and this is verified by experimenting with a large flat wooden board which was moved about to various positions. The tone rose in pitch when the board was moved vertically upwards towards the observing ear. By calculation, it is found at what positions certain pitches should be expected, and those results are in fair agreement with experiment. The same effects are observed and verified near a small waterfall. The phenomenon is compared to the action of the Fresnel mirrors and the Lloyd's mirrors in light. The source of sound emits a mixture of harmonic vibrations of different periods, so that after reflection a kind of sound spectrum is formed by the interference of the different constituents. At different points near the reflecting surface, the different harmonic constituents stand out. J. W. P.

477. *Study of Speech by Microphonic Currents.* **A. Blondel.** (Comptes Rendus, 133. pp. 786–789, Nov. 11, 1901.)—The author describes a new method for following the transformations of sound vibrations into electric oscillations by making use of a microphone, and of a reinforcing circuit. The resonance apparatus comprised three circuits, with elevating and lowering transformers as well as a condenser regulated to give the maxima of sound and accuracy. A bifilar oscillograph was employed and was branched between the secondary terminals of the second transformer. Curves are given corresponding with the vowels *a, e, i, o,* sung as nearly as possible on the note la_3, and these show very distinctly the periodicity of the phenomenon and the differences between the several vowels. T. H. P.

REFERENCE.

478. *A Century of Progress in Acoustics.* **J. Loudon.** (Science, 14. pp. 987–995, Dec. 27, 1901. Presidential address to the American Association for the Advancement of Science.)

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

479. *Unipolar Rotation.* **G. R. Olshausen.** (Ann. d. Physik, 6. 4. pp. 681–725, Dec. 5, 1901. Abstract from the Berlin Inaugural Dissertation.)—The Biot-Savart law of action between electric currents and magnets leads, according to some writers, more particularly E. Lecher [see Abstract No. 94 (1900)], to inconsistent results. And certain experiments have been made with specially designed apparatus by Lecher, König, and Pohl with a view to prove the incorrectness of the law.

The present writer maintains that if all the electric field is duly brought into account, results are obtained in accordance with theory, and there is no inconsistency. He first enunciates the law in the following form: "The action of an elementary electric current on a magnetic pole is inversely proportional to the square of the distance r between the two, and directly proportional to the sine of the angle which r makes with the direction of the current. He assumes also that if the current element acts on the pole with a definite force applied at the pole, the pole acts on the current element with an equal parallel and oppositely directed force applied at the element."

Then, after explaining the theory of the Biot-Savart law, he describes and discusses the three experiments of Lecher, König, and Pohl.

The results of the author's investigation are summarised in five conclusions, of which the following are of general application: (1) That in the form above given the law leads to results consistent both with these experiments and with theory; (2) any definite portion of an electric current contributes, or does not contribute, to the total result, viz., moment of rotation of the pole about an axis, according to the point of view taken; we may say, namely, that the current acts as a whole; (3) the law has no meaning except as applied to the entire current, supposed closed; (4) it is impossible by any measurements to determine to which part of a closed circuit the action on the magnet is due. S. H. B.

480. *Electromotive Force Produced by Unipolar Induction.* **O. Grotrian.** (Ann. d. Physik, 6. 4. pp. 794–817, Dec., 1901.)—A cylindrical magnet is rotated, between coned screw-ends, about its axis. The motor used drives it at speeds up to 30 revolutions per second. Brushes touch its surface at the centre of the magnet, and also on the framework beyond its two ends. On connecting the brushes to a quadrant electrometer, a potential difference as much as 2 millivolts was found. Magnetic lines of force are cut in the rotation, and theory shows that the e.m.f. should be $E = 4\pi\mu v$, where μ is the pole-strength, and v the frequency of rotation per second. By measuring the magnetic moment of the magnet, and hence μ, the author gets a theoretical value of E. His results are: (1) In open circuit of an ordinary unipolar machine there exists free electricity due to induction. (2) The potential difference of this free electricity is equal to the total e.m.f. running in the closed circuit. (3) Reckoning from the free magnetism, a value was found for the e.m.f. about 15 per cent. less than the value found in practice. The question as to the cause of this discrepancy remains at present open. P. E. S.

481. *Production of a Magnetic Field by Electric Convection.* **A. Righi.** (N. Cimento, 5. pp. 233–256, Oct. 1901.)—The following four analogous phenomena, following on electromagnetic theory, have not yet been definitely verified by experiment: (1) An electric charge in motion should produce a magnetic field. (2) A varying magnetic field should produce an electric field. (3) A magnetic pole in motion should produce an electric field. (4) A varying electric field should produce a magnetic field. Attempts have been made to verify the first two phenomena, but the last two have not yet been experimentally tested.

The author then reviews critically the various experiments made. Rowland first experimented on the first phenomenon, observing the effect of a charged rotating disc on a magnetic needle. He obtained results corresponding to the effect indicated by theory. Lecher, in 1884, repeated the experiments with a similar apparatus, but obtained no deflection of the needle. Röntgen later replaced the charged disc by a disc of insulating material, charged inductively by two fixed metal discs, one on each side of it. Deflections were produced which, however, he afterwards found to be due to other causes than a charge on the rotating disc. Himstedt repeated Rowland's experiment, using two rotating glass discs, rendered conducting by graphite, with the lower needle of an astatic pair between the discs; the use of graphite reduced the Foucault currents, due to the earth's magnetism, to a minimum. The deflections obtained were large and corresponded with those calculated, but were not proportional to the potentials of the discs. In 1889 Rowland and Hutchinson repeated Himstedt's experiments, and obtained deflections corresponding to the calculated, but which were not equal when the sense of rotation of the discs was changed. In 1900 Crémieu made the experiment with an apparatus of modified form, and obtained a negative result [see Abstract No. 1666 (1900)]. Later he repeated the experiment with an apparatus more similar to Rowland's, also with negative results [see Abstract No. 144 (1901)]; in this, between the moving charge and the needle, were a mica disc with tin-foil sectors and a brass disc; on removing the brass disc, when the arrangement corresponded exactly with Rowland's, he obtained deflections similar both in magnitude and sense to Rowland's. These, however, he attributes to electrostatic action and not to magnetic effects. Crémieu again had negative results from a different form of apparatus [see Abstract No. 1916 (1901)]. In 1901 Pender repeated Rowland's experiments under his direction, substituting a coil connected to a galvanometer for the magnetic needle, and obtained results agreeing very closely with theory [see Abstract No. 2140 (1901)]. Adams confirmed these results by an apparatus of somewhat different design (see Abstract No. 2136 (1901)]. The author criticises the various experiments at length, and points out that Crémieu makes the assumption that a metal sheet between the moving charge and the needle cannot affect the magnetic action of the former on the latter. The author, however, thinks it possible that charges may be induced in this sheet which neutralise the action, the sheet, from its position and shape, acting differently from the metal cage surrounding the needle in Rowland's experiments. On the other hand he points out that Rowland's experiments are not free from objections, as the results showed that all the sources of error had not been found or completely eliminated. Nevertheless he considers the evidence to be in favour of the truth of the first phenomenon.

The second phenomenon was tested experimentally by Lodge in 1889, by observing the motion of a gold leaf in a varying magnetic field. He obtained results concordant with theory, but did not consider the experiment decisive

Crémieu in 1900 obtained a negative result with a different apparatus [see Abstract No. 106 (1901)], but Wilson showed that in this apparatus deflections opposite to those sought for must tend to be produced by other causes, and that consequently the fact that they were not produced proves the existence of forces due to the second phenomenon [see Abstract No. 2188 (1901)]. The author then describes an arrangement designed by himself for testing the second phenomenon. A needle consisting of a tube of cigarette paper is charged by a dry pile, and suspended in the hollow core of a powerful electromagnet, so as to hang in the gap. He shows that owing to want of perfect symmetry in the needle, the suspension and the field, deflections may be produced by various causes, and he describes the various precautions taken to eliminate these deflections. He obtained the results expected, but the tests were not sufficiently free from error to be considered decisive.

Reviewing the experimental difficulties attendant on the verification of the four phenomenon, he considers that the second and third offer fewer difficulties than the first and fourth, and points out that the verification of any one entails the truth of all four. G. H. B.

482. *Electric Convection.* **V. Crémieu.** (Soc. Franç. Phys., Séances, 2. pp. 152–170, 1901.)—This paper contains a *résumé* of former experiments and an account of further ones, confirming the conclusion that electric convection does not produce any magnetic effect. Also, convection may maintain a constant difference of potential between two points connected by a metallic conductor along which conductor there is a magnetic field, the lines of force in which are not closed; there may thus be open currents. [Compare Abstracts Nos. 1666 (1900), 144 and 1100 (1901), 56 and 316 (1902).] A. D.

483. *Electromagnetic Units.* **G. Giorgi.** (Elettricità, Milan, 20. pp. 787–788, Dec. 14, 1901. Abstract of a paper read before the Italian Electrotechnical Association, Oct. 13, 1901.)—Heaviside's suggestion as to the "rationalisation" of the electromagnetic units and the elimination of the 4π from the formulæ is explained. The author starts from the equation Work $= ei$ and Work $= fg$, where f is the magnetomotive force and g the magnetic current (rationalised formula), and the circuital equations $e = \pm g$ and $f = \pm i$; he then, retaining the watt, the volt, and the ampere, shows that the corresponding terms are the following, the magnetomotive force being measured with reference to ampere-turns and thus eliminating the π.

Electromotive Force = volt = magnetic current.
Electric Current = ampere = magnetomotive force.
Quantity of Magnetism = weber = electromotive impulse.
Quantity of Electricity = coulomb = magnetomotive impulse.
Electric Resistance = ohm = magnetic conductance.
Magnetic Resistance = mho = electric conductance.
Electrostatic inductance = farad = magnetic self-induction.
Magnetic Inductance = henry = electric self-induction.
Electrostatic Reluctance = farad^{-1} = (magnetic mobility).
Magnetic Reluctance = henry^{-1} = (electric mobility).

All this works out if an m.-k.-s. (metre, kilogramme, second) system be adopted; and there is no need for c.g.s units. Such an m.k.s. system would be not only absolute, but rationalised, and the same for electrostatic and electromagnetic units. On this system K represents farads per metre, and instead of μ we would have, say, λ, the magnetic inductivity in absolute units, while μ stands for λ/λ_0, the ratio between the inductivity of the medium and that of the ether. For the ether, $K_0 = 0{\cdot}000000,000008,842$ and $\lambda_0 = 0{\cdot}000001,256637$. A. D.

484. *Electrostatic Equilibrium of two Parallel, Uniformly Charged Cylinders of Revolution.* **J. B. Pomey.** (Écl. Électr. 29. pp. 457–463, Dec. 28, 1901.)—Two parallel telegraph wires, each of which is of a length much greater than the radius of its cross section, are mathematically to be considered as two parallel straight cylinders. Each being uniformly charged with electricity, the problem is to find the potential at any point, and hence the capacity of either wire. It is a problem in two dimensions, a plane being taken at right-angles to the wires, which are represented by two circles on the plane. If we can find a function p which has a constant value round the contour of either circle satisfies the condition $\Delta p = 0$ at all points in the plane exterior to either circle, and is equal to log r at an infinite distance, r being measured from either circle, that function must be the required potential.

Two conjugate points are taken, a in the larger, a' in the smaller circle, and r, r', are the distances of any point from a, a', respectively. At any point on the contour of the larger circle $r/r' = \mu$ $(\mu < 1)$ and the radius is $aa'\mu/(1-\mu^2)$. At any point on the contour of the smaller circle $r/r' = \lambda$ $(\lambda > 1)$ and the radius is $aa'\lambda/(\lambda^2 - 1)$.

The author begins with the function—

$$F = \log\left\{\tan(A + iB) - \tan C\right\}, \text{ A, B, C being real.}$$

P and Q, the real and imaginary parts respectively of this expression, are first determined in terms of A, B, and C.

He then assumes that—

$$A = \frac{\pi}{2}\log\left(\frac{1}{\lambda\mu}\frac{r}{r'}\right)\Big/\log\frac{\lambda}{\mu} \text{ and } B_\kappa = \frac{\pi}{2}\frac{1}{\log\frac{\lambda}{\mu}}(\phi - \phi' + 2\kappa\pi),$$

ϕ, ϕ', being the angles made with aa' by r, r' respectively, κ a quantity which assumes all integral values, and B_κ the value of B for a particular value of κ.

He also writes—

$$C = -\frac{\pi}{2}\frac{\log\lambda + \log\mu}{\log\lambda - \log\mu}.$$

The required potential function for the case in which the sum of the charges is -1, is found to be—

$$p = \sum_{-\infty}^{+\infty}\left(P_\kappa - \frac{1}{2}\log\frac{1}{\cos 2C}\right) + \text{a constant.}$$

It is shown (1) that the series converges; (2) it satisfies $\Delta p = 0$; (3) $p = 0$ on the contour of either circle; (4) $p = \log\frac{1}{r}$ at an infinite distance. It is shown also that infinite values of the logarithm cannot occur at any point exterior to the two circles. The distribution of the charge -1 between the two wires is then determined, and thence the writer proceeds to the general case in which the charges on the wires are q, q'. S. H. B.

485. *Electric Ions in the Higher Layers of the Air.* **H. Ebert.** (Terrestrial Magnetism, 6. pp. 97–118, Oct., 1901.)—Following the methods of Elster and Geitel [see Abstracts Nos. 2023 (1900) and 1918 (1901)], but using free balloons the following results are found: (1) Observations of atmospheric electricity can be taken accurately and easily with the other usual observatory work by the balloon method. (2) At increased heights there is an undoubted increase in the speed of discharge, independent of the discharges on the earth, which latter are a disturbing factor in mountain observations. (3) Up to 3,000 metres it was found that negative discharge occurs faster than positive. At greater heights the rates of discharge become more and more nearly equal as we ascend. (4) The increase in the rate of discharge with increase in height is not such as to enable the relation to be expressed in a simple formula with few constants; hence it is to be supposed that the physical conditions, specially as to moisture, in each layer through which the balloon passes, have preponderating influence. (5) In dry, clear air the rate of discharge is nearly as great as near the earth; but in damp air, specially when the dew-point is reached or light clouds exist at the point in question, the discharge is much reduced. (6) Great rate of discharge occurs when, the air having been clear and air currents small for many days, ions exist in large quantity. [See also Abstract No. 1917 (1901).] P. E. S.

486. *Observation of Distant Storms and Study of Atmospheric Electricity.* **T. Tommasina.** (Comptes Rendus, 133. pp. 1001–1003, Dec. 9, 1901.)—By means of the electroradiophone already described [see Abstract No. 489 (1901)], the author has heard storms, in one case 200 km., in another case 400 km. away. A curious point is that in some thunderstorms the radiophone is not affected, from which the author concludes that the lightning discharge in those cases is non-oscillating. The main purpose of the paper is to describe the variations in atmospheric electricity perceived by means of the electroradiophone when the author was on the look out for distant storms.

He heard slight sounds at regular intervals; these were not connected at all with storms or rain, but were purely due to ordinary atmospheric electricity entering the antenna of the instrument. As the result of a set of observations from the middle of October, 1901, for the next three weeks it was found that a maximum of electricity in the morning had a progressive diminution until it finally disappeared, and only one oscillation in the curve occurred, having its maximum in the early hours of the night. P. E. S.

DISCHARGE AND OSCILLATIONS.

487. *Conditions Controlling Potential Fall at Electrodes in Vacuum-tube Discharge.* **C. A. Skinner.** (Phil. Mag. 2. pp. 616–638, Dec., 1901. Paper read before the American Association for the Advancement of Science, Aug., 1901.)—An experimental investigation showing that the high potential required to produce a discharge between electrodes in a vacuum-tube, when these are placed close together, is due to a drop of potential between metal and gas, and examining the conditions controlling this drop of potential. The gas used was purified atmospheric nitrogen. The variation of the drop of potential at the electrodes, with their distance apart, is shown by a table and by curves. As the anode is moved towards the kathode, the drop at the anode remains constant along the positive column; within the Faraday dark space it first increases to a certain maximum value, then falls rapidly to a value approximately zero in the negative glow; retains this zero value throughout the negative glow, but increases very rapidly on entering the kathode dark space. Comparing the curves with those of H. A. Wilson for

cross-conductivity [see Abstract No. 1669 (1900)], the author concludes that the conditions which increase the cross-conductivity decrease the drop of potential at the anode; and, therefore, if the former depends simply on degree of ionisation, the anode drop is decreased by increased ionisation. The author, however, introduces the factor of the velocity of the discharging ions, and explains the variation in the drop in the different parts of the tube by saying that, other conditions being the same, the greater the velocity of the discharging ions, the greater the drop at the anode. The same argument applies to the fall of potential at the kathode, for which tables are also given. Some of the results in these tables show that, when the electrodes are close together, the gradient in the gas is inappreciable, and that the high discharge-potential is wholly made up of the drops at the electrodes. The variation of the potential fall at the electrodes with current-density and with gas-pressure is then investigated. With moderate current-densities the anode drop is constant, other conditions being constant, but it increases with gas pressure, that is, it increases with the force with which the negative ion is driven against the anode. The kathode fall increases with increasing currents, decreases with increase of pressure. The author deduces a formula giving the kathode-fall within a given range of pressures for the particular metal and position of electrode and the gas used. From investigation of the effect of the area of the kathode on the drop at that electrode, the conclusion is drawn that the kathode-drop may be designated as a linear function of the current-density. Having given curves showing the effect of the kind of metal on the kathode-fall, the author makes the *general* conclusion that for a plane kathode the relation between kathode-fall V, current-density i, and gas-pressure p, may be expressed by the equation—

$$V = C + \frac{c}{p}(i - a),$$

where a is a constant; c, a constant depending on gas used; C, limiting value of kathode-drop for infinite pressure, depending both on metal and gas used. Finally, the author compares the results at the kathode with those at the anode. W. C. H.

488. *Electrification of the Air by Glow Discharge.* **O. Lehmann.** (Ann. d. Physik, 6. 4. pp. 661–680, Dec., 1901.)—The following are the principal conclusions at which the author arrives as the result of his experiments:—

(1) Convective transfer of electricity by glow discharge at a point cannot be considered as due to capacity of the air to act as a conductor. (2) An electrically charged conductor (or insulator) brought into a unipolar electrical wind does not lose its charge if the electrifications are similar, even if its potential is much higher than that of the electrified air. In the opposite case it loses its charge completely, and acquires the opposite one, corresponding to the prevailing potential at the particular place. (3) Ordinary metallic sounds do not give the true course of the equipotential surfaces and flow lines, especially with low potential values; these are given well, however, by drop or flame collectors, in so far as they do not themselves give rise to change in the electrical condition. (4) Positive and negative electrified air diffuse in the same way. The electrification can therefore not be conditioned by the presence of free moving electrified particles of different nature (electrons). (5) The convective flow fills the whole space around the point. When lycopodium powder is sprinkled in the neighbourhood, the region

mapped out by the Kundt's figures thus obtained is not the discharge region, but it is the region in which the electric wind gives rise to sufficiently high potential differences to produce the glow discharge on striking against the plate. (6) Behind an insulating plate, set up perpendicularly to the lines of flow, there exists a space free from electrified air (electric shadow). (7) When an electric wind proceeds from two points placed opposite to each other, a rotatory movement is produced in the air, and a varying arrangement of the stream lines of the electrical particles takes place. (8) In the region in which both positively and negatively electrified air is present, the air is apparently conducting. (9) The relation between the velocities of discharge of conductors charged oppositely, but to an equal extent, allows of drawing a conclusion as to the mass relation of positive and negative electric particles at the place in question. (10) The electric winds proceeding from the two points combine, with equal value of the pressure at both electrodes, only partially, a greater part escaping unchanged to the walls of the room. The electric particles do not follow the lines of force which exist before the beginning of the discharge, but the lines of force of the field produced by themselves, which from the first is very different. (11) With unequal supply of electricity at the two electrodes, the electrified air appearing in greater quantity envelops also the opposite electrode. (12) Two sounds which are placed only in positive or only in negative electric wind, give on being joined a current only until the sound at the place of lower potential has attained the potential of the other; on the other hand, two sounds which are put one in positive and the other in negative wind, give a continuous current. (13) Alternating currents produce no electric wind, and do not make the air apparently conducting. J. J. S.

489. *Disruptive Discharge in Electrolytes.* **H. Bagard.** (Comptes Rendus, 133. pp. 927–929, Dec. 2, 1901.)—In order to obtain the discharge in conducting liquids with simple apparatus, it is important first of all to reduce as much as possible the surfaces of the metallic conductors between which it is sought to produce a spark in the liquid. The author employs two metal wires, 1 mm. in diameter, arranged horizontally in a line, and insulated from the liquid by a thick sheath of solid dielectric, such as ebonite, up to the immediate neighbourhood of the free extremities. In the second place, it is necessary to employ one of the known methods of the dynamical discharge. For example, two insulated Leyden jars were taken, and their inner coatings joined respectively to the two poles of an electrical machine, and to the two balls of an ordinary discharging apparatus, operating in air. The outer coatings were joined to the two branches of the discharger in the liquid B. This last, owing to the conduction of the liquid, maintains the equality of the potentials of these two coatings at the time of charge, which is relatively slow. But if the discharger, A, is regulated for a sufficient explosive potential, when a discharge of the inner coatings is produced, the quick discharge which tends to take place between the outer coatings is not able to occur by simple electrolytic conduction, and a spark passes across the dielectric. With large surfaces the discharge would happen exclusively by conduction. The liquid discharger may be placed in an independent circuit. The explosive distance may be raised to 3 mm. and more in solutions of high conductivity, such as copper sulphate and sulphuric acid.

If an induction coil be used instead of isolated sparks in the liquid, a close succession of sparks may be obtained, and their frequency may be regulated at will. J. J. S.

490. *Length of Break-Spark in Inductive Circuit.* **R. Beattie.** (Phil. Mag. 2. pp. 658–658, Dec., 1901.)—This paper gives the results of measurements of the length of the spark which appears on suddenly breaking an inductive, current-carrying, electric circuit, the object being to gain some definite information regarding the influence of the material of the break-poles on the spark-length. One of the poles was held permanently in position, while the other could be rapidly drawn away by a device which secured uniformity in breaking the circuit. The time taken by this moving pole to travel l centimetres was $0{\cdot}027\sqrt{l}$ seconds, and as the longest sparks observed were about 7 cm. in length, their duration was thus 0·07 second. The accompanying table gives the results of the experiments, shown also by curves in the paper.

Current in Amperes.	SPARK-LENGTH IN CENTIMETRES.												
	Iron.	Bismuth.	Copper.	Platinum.		Carbon.	Tin.	Nickel.	Aluminium.		Zinc.	Lead.	
				Fixed pole positive.	Fixed pole negative.				Fixed pole positive.	Fixed pole negative.		Fixed pole positive.	Fixed pole negative.
1·2	...	0·2	0·15	...	...	0·05	0·15	0·05	0·2	0·2	0·15	0·2	0·2
1·8	0·15	0·6	0·30	0·15	0·15	0·15	0·38	0·30	0·4	0·4	0·30	0·5	0·5
2·4	0·38	—	—	—	—	—	—	—	—	—	—	—	—
3·0	0·62	1·4	0·70	0·31	0·31	0·40	0·94	0·90	0·75	0·75	0·75	1·4	1·4
6·0	2·25	2·5	1·9	1·25	1·4	1·7	2·7	2·5	1·9	1·9	2·25	2·8	2·9
9·0	3·75	3·5	2·9	2·25	2·5	3·4	4·0	4·0	3·1	3·1	3·4	3·75	4·4
12·0	5·13	4·0	4·0	3·25	3·7	5·3	5·2	5·4	4·35	4·5	4·4	4·7	5·4
15·0	6·25	4·6	5·0	4·37	5·0	7·2	6·6	6·5	5·6	6·1	5·4	5·5	6·5

The curves show that the spark-length varies with the current in different ways for different materials, so that the material which gives the longest spark with a particular current does not necessarily give the longest spark with another current. But the most interesting point brought out is in connection with the behaviour of the different materials on reversal of the current. With the metals, iron, copper, tin, nickel, zinc, and with carbon, reversal of current produces no perceptible difference in the spark-length; but with lead, platinum, and aluminium poles the spark-length for the larger currents is notably greater when the fixed pole is negative than when it is positive. W. C. H.

491. *Characteristics of the Spark of an Oscillating Discharge.* **C. Tissot.** (Comptes Rendus, 133. pp. 929–931, Dec. 2, 1901.)—Further remarks are made on the method of observing the spark previously described [see Abstract No. 1518 (1901)], in which a rotating mirror and cylindrical lens are used. It has been found, on micrometric examination, that the images of the successive sparks are not rigorously equidistant. The first interval is always distinctly greater than the others. The following intervals successively decrease very slightly. While the differences are small they seem not to be accidental, for the same tendency appears in all the experiments.

The first interval appears to depend upon the explosive distance, and increases with it. Hemsalech has shown that there exists an important difference between the first spark of an oscillating discharge and the following ones. In the first the spectral lines due to air only appear, whilst the lines of the metal appear in the others. J. J. S.

492. *Resonance of Electric Waves Determined by Coherer.* **F. Kiebitz.** (Ann. d. Physik, 6. 4. pp. 741–753, Dec., 1901.)—Continuing the investigations described in Abstract No. 1929 (1901), the author finds that a coherer allows a determination of resonance to be made provided care is taken that the wave trains sent are always precisely alike. This was done by using with the induction coil a vibrating interrupter of considerable mass. The best results were obtained from iron coherers vigorously shaken. The best arrangement of receiver was found to be that of two insulated wires, each a quarter wave-length long, one on each end of the coherer. The coherer was also found to work on a circular receiver whose length was a whole wave-length. E. H. B.

493. *Hertz Waves in Water.* **C. Gutton.** (Journ. de Physique, 8. pp. 752–756, Dec., 1901.)—The resonator used was a copper ring 36 cm. diameter and 0·3 cm. thick. Waves were passed from a Hertz vibrator along two parallel wires 38 cm. apart, which at 250 cm. from the vibrator passed into a tub to hold the resonator, and afterwards extended a distance of 400 cm. within a long trough, being 4 cm. apart and connected by a bridge. With first air, then water in tub and trough, the wave-lengths were found to be invariable, the resonator either in or perpendicular to the plane of the wires. But when the resonator was kept in air and the wires immersed in water the wave-length was reduced from $\frac{\lambda}{2} = 145$ cm. in air to $\frac{\lambda}{2} = 17{\cdot}5$ cm. in water, these numbers giving 8·3 as the refractive index of water for the waves. These experiments contradict Turpain's statement that the period of a resonator is independent of the medium in which it is immersed. G. E. A.

494. *Oscillations in the Hertz Vibrator.* **K. R. Johnson.** (Journ. de Physique, 8. pp. 756–759, Dec., 1901.)—An error in an equation in a previous paper [see Abstract No. 1927 (1901)] is corrected. The oscillations which take place in each half of the vibrator resemble those in a closed organ-pipe, the ball corresponding to the open end of the pipe and the sparks to the intermittent compressions caused by the movement of the reed. It is not necessary to assume a metallic conductivity in the spark-gap of the Hertz vibrator. G. E. A.

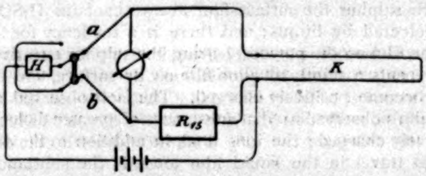
ELECTRICAL PROPERTIES AND INSTRUMENTS.

495. *Contact Electricity.* **O. Knoblauch.** (Zeitschr. Phys. Chem. 39. pp. 225–244, Dec. 5, 1901.)—Platinum and paraffin are charged, upon contact with powders and subsequent separation, in general positively if these powders possess acid properties when dissolved in water, negatively if they are alkaline, positively or negatively in about equal numbers of cases if they are neutral. Sulphur generally becomes negative, and is positively charged only after contact with some acids; glass generally becomes posi-

tive, and is negatively charged only after contact with some bases. Some organic dye-stuffs in powder, not necessarily bases, but also salts, give a strongly negative charge to platinum, paraffin, sulphur, and glass. The author develops the theory that these differences are due to the relative velocities of ions in the surface-films of moisture on the plate and the powder; for example, if powdered tartaric acid be thrown on to platinum there is diffusion between the surface film on the powder and that on the platinum, and the hydrogen ions in the former load the platinum plate more rapidly than the acid-radicle ions do; so that if the powder be thrown off before saturation-equilibrium has been established, the platinum remains positively charged. The potential-difference would therefore depend on the duration of the contact. With salts the difference between the velocity of the ions is much smaller, and trifling causes affect the result, which is variable. With sulphur the surface-film always contains H_2SO_4, which can (Emich) be detected by litmus; and there is a tendency for the H ions to wander into the film on the powder, leaving the sulphur negatively charged; while glass presents a faintly alkaline film on its surface, and the tendency is for this to become positively charged. The facts observed are in agreement with Coehn's observation that substances of greater dielectric constant become positively charged; the ions tend, in addition to the above process of diffusion, to travel in the liquid film towards the substance of greater dielectric constant. The greater their velocity the more rapidly they accumulate towards its surface, with effects analogous to the preceding, but which may or may not concur with those of ordinary diffusion of ions. This latter is the dominant factor in cases of acids or bases, but may have little or no effect where the substances are neutral. The theory of accumulation by diffusion does not apply to prolonged contacts or to contact between a solid and a liquid; in such cases Coehn's principle is more applicable. It does, however, apply to the contact of two metals in a gas, oxidation-products being dissolved in the surface-film of moisture; there are more OH-ions about the surface of a more oxidisable metal, and these, leaving that metal, leave it positively charged. A. D.

496. *Measurement of Mutual Induction by the Electro-dynamometer.* **R. Manzetti.** (Accad. Lincei, Atti, 10. pp. 179–186, Oct. 20, 1901.)—The paper describes the measurement of very small coefficients of mutual induction by means of alternate currents and a differential dynamometer designed by the author. Owing to the difficulties attendant on the use of the ballistic galvanometer, due to variations of zero, of H and of the strength of the controlling magnet, when great sensitiveness is required, the author considers the method described to be superior to the ordinary one. The differential dynamometer has two coils, one on each side of the moving system, with their axes parallel, but one above the other. The moving system consists of two bundles of soft iron wire fixed to an aluminium stem, one bundle before each coil. The two bundles are at right-angles to each other, each making an angle of 45° with the axis of the coil. By adjusting the position of one coil, the instrument can be made to give no deflection when an alternate current is passed through the two coils in series. The coefficient of mutual induction to be measured was compared with that of a standard pair of coils. The primaries were connected in series, and the secondaries, one to each coil of the dynamometer with an adjustable resistance. When balance is obtained the coefficients of mutual induction are to one another as the resistances of the two secondary circuits. G. H. B.

497. *Testing Telegraph Cables.* **K. Strecker.** (Elektrotechn. Zeitschr. 22. pp. 959–960, Nov. 14, 1901. Paper read before the Elektrotechn. Verein, Oct. 22, 1901.)—The author first describes the weekly conductivity and insulation-tests as normally carried out in Germany, in which the variation in resistance of the gutta-percha insulation with temperature is allowed for, using the formula $r_t = r_0 . f^t$, where $f = 0{\cdot}87$ to $0{\cdot}89$, to reduce the resistance to 15° C. In order to simplify the measurements and calculations, and increase the accuracy, the following arrangements are suggested, viz.: In order to obtain the mean temperature of the conductors without calculation, two of the cores are looped, as at K, and the open ends connected to a Wheatstone bridge as shown: *a* and *b* are each 1,000 ohms, and an auxiliary resistance H is employed which, by means of a double-pole switch, can be added either to *a* or to *b*. R_{15} is a resistance box adjusted to the normal resistance of the cable at 15° C., which is previously determined. By adjusting H, a balance is obtained when $R_t : R_{15} :: (a + H) : b$, whence—



$$\frac{R_t - R_{15}}{R_{15}} = \frac{(a + H) - b}{b} = \frac{H}{b},$$

and $t = 15 + H/8{\cdot}7$, that is to say, 1° C. has to be reckoned for each 8·7 ohms in H. H is accordingly divided into units of 8·7 ohms, and contains 1 step of 10°, 9 of 1°, and 9 of 0·1° C. It is added to the arm *a* when the temperature of the cable is higher than 15° C., and to the arm *b* when the temperature is lower than 15°. The formula for the resistance *r* of the insulation per kilometre reduced to 15° C. is—

$$r_{15} = 10^5 . \frac{Nz}{nZ} . f^{15-t} . L,$$

using the deflection method, where N = the number of scale divisions through which the galvanometer is deflected when connected to earth through 10^5 ohms with a 100-volt battery. The galvanometer is provided with an Ayrton shunt of which Z ohms are in the main circuit. The 10^5 ohm resistance is then replaced by the core of the cable and the galvanometer deflected through *n* scale divisions, the shunt having *z* ohms in the main circuit. L = the length of the cable in kilometres. This can be simplified by drawing a curve, a rectangular hyperbola, connecting *n* and r_t from the above formula, neglecting the term f^{15-t}, taking r_t as abscissæ and N, *z*, Z as constants for the same cable. On the same paper a number of radius vectors are drawn at angles ϵ corresponding to different temperatures, where $\tan \epsilon = r_t : r_{15} = f^{t-15}$, and values of r_t are also taken as abscissæ. This diagram is used as follows: The ordinate corresponding to the observed deflection is found on the hyperbola, and also the corresponding abscissa giving the resistance r_t. From here passing upward the point is found where the ordinate cuts the temperature vector, for example, for 16°, and finds the ordinate to this r_{15}. This can be left to find r_t, then to pass directly from the hyperbola to the temperature vector, and finally to read off on the axis of y, the resistance of 1 kilometre of cable reduced to 15°. The whole calculation is thus effected graphically. The paper also describes the construction of a slide-rule for performing the above calculation. C. K. F.

498. *Examination of Very Small Charges of Electricity.* **R. Blondlot.** (Comptes Rendus, 133. pp. 717–719, Nov. 4, 1901.)—The apparatus employed consists essentially of a pair of 2 × 2·4 cm. brass plates, one of which is connected to earth and the other insulated, and having suspended between them by a quartz fibre an insulated needle formed of a bent blade of aluminium. The charge communicated to the insulated brass plate causes a deviation of the needle proportional to the square of the charge. Devices are employed for multiplying the action of the charges. D. H. J.

499. *Wehnelt Interrupter.* **K. R. Johnson.** (Phys. Zeitschr. 3. pp. 105–106, Dec. 15, 1901.)—In a former communication [see Abstract No. 2413 (1901)] the author showed how to arrive at an expression for the periodicity of the Wehnelt interrupter, in terms of the length of the circuit, the velocity of light, and the "dielectric constant" of the medium surrounding the platinum electrode. An expression for the periodicity has also been obtained by H. T. Simon [see Abstract No. 1520 (1899)] in terms of the resistance, self-induction, and e.m.f. of the circuit. The author compares his equation with that of H. T. Simon. As, however, the results are not supported by experiment no value can be attached to them. R. A.

500. *Phasemeter for Three-phase Circuits.* **R. Arnò.** (Elettricità, Milan, 20. pp. 755–756, Nov. 30, 1901. Abstract of a paper read before the Associazione Elettrotecnica Italiana.)—The author describes a modification of the method suggested by him of measuring the phase-difference in three-phase circuits by means of an ordinary wattmeter. If a, b, and c represent the three conductors of the circuit, in the original method, the current coil is inserted in circuit a, and the pressure coil joined first between a and the neutral point, and then between b and c; the ratio of the two readings then gives $\sqrt{3} \tan \phi$. The modification consists in having the pressure coil wound double. One coil is joined between a and b, and the other first between a and c, and then between c and a, the two being in series in each case. The centre of the coil is then at the same pressure as the current coil, and, if the greater part of the pressure be absorbed in external resistances, there is no large difference of potential in the instrument. G. H. B.

501. *The Lloyd-Creak Dip-Circle.* (Terrestrial Magnetism, 6. pp. 119–121, Oct., 1901.)—This differs from the Lloyd Circle in certain points of construction and usage as follows: (1) The circle is divided to every 10′, instead of to 15′; (2) the upper half of the jewel bearings is removable, so that either the reversible dip needle or the non-reversible intensity needle may be inserted; (3) a lifter is used when the apparatus is not in action; (4) a ground glass back, when illuminated even by a candle, gives ample light for reading the microscopes; (5) when the instrument rests on the gimbal table, the circle can be readily placed in the magnetic meridian; (6) the weighted needle is pierced for inserting weight in either end of the needle. The instrument is specially intended for high values of the total intensity. Sketches are given. P. E. S.

ALTERNATING CURRENTS AND MAGNETISM.

502. *Action of Direct-current Armatures on Alternating Currents.* **H. Poincaré.** (Écl. Électr. 30. pp. 77–81, Jan. 18, 1902.)—This article has been inspired by the discussion of this subject by Leblanc, Latour, and Heyland [see Abstracts Nos. 80, 334, and 335 (1902)]. Since experiment has shown that Latour is correct, the author examines closely the reasoning of Leblanc. First of all he considers the general theory. Instead of dividing the time into intervals equal to the period of the polyphase current, he takes for his period the time that elapses from the moment a brush leaves a commutator-bar to the moment it leaves the next. He proves that if the number of segments were infinite, and the speed of the armature suitable, then the magnetic field would be absolutely fixed in space. In practice it is not absolutely fixed, but at the end of each period it is in the same position as it was at the beginning of the period. It therefore acts as if it had no appreciable self-inductance. In order to show where Leblanc's reasoning is incorrect he points out that two separate cases have to be considered in each period. In the first place the brush rests on one commutator-bar and in the second the act of commutation takes place. In the first, as Leblanc mentions, the field turns round with the armature, but in the second, which is very brief, it is brought back to its original position. A. R.

503. *Demagnetising Factors of Cylindrical Rods.* **C. Benedicks.** (Ann. d. Physik, 6. 4. pp. 726–740, Dec. 5, 1901.)—The demagnetising factors of cylindrical rods cannot be determined theoretically, as is possible for ellipsoids of rotation; the author has made experiments to determine them, employing both magnetometric and ballistic methods. The experiments were confined to a single specimen of cast steel, 20 cm. long by 0·8 cm. diameter, the dimension ratio being therefore 25. Curves of I and H were taken by magnetometric and ballistic methods; in the latter I was calculated from the formula $I=(B-H)/(4\pi-N)$, where N is the almost negligible demagnetising factor at the centre of the bar. The ratio of the intensities of magnetisation found by the tried methods respectively increased from 0·687 at $H=23$ to 0·84 at $H=206$. The rod was then turned down to an ellipsoid of rotation; measurements taken before and after annealing showed that the turning had no appreciable effect on the magnetic properties. The IH curve was taken by the magnetometric method, and the shearing curves drawn for the two curves of the cylindrical rod. That for the ballistic curve is a straight line to $I=800$, giving a demagnetising factor of 0·0444; the value given by Du Bois for the dimension ratio 25 is 0·0533. At higher magnetisations, the demagnetisation diminishes rapidly and finally vanishes. The shearing curve for the curve obtained by the magnetometric method is also a straight line to $I=700$, giving a demagnetising factor of 0·0658; Maun's value for soft iron of the same dimension ratio is 0·0648. At higher magnetisations the demagnetisation increases very rapidly. The difference between the demagnetising factors applicable to measurements made by magnetometric and ballistic methods, is due to the fact that in the former case the field strength is corrected to the mean value for the whole cylinder, while in the latter it is corrected to the maximum value in the centre of the cylinder. Du Bois' values of the demagnetisation factors were derived from Ewing's ballistic measurements for dimension ratios above 50, and from Tanakadaté's magnetometric measurements for ratios below 50. The latter are too high when referred to ballistic measurements, and too low when referred to magnetometric. G. H. B.

504. *Residual Magnetism in Different Steels.* **A. Abt.** (Ann. d. Physik, 6. 4. pp. 774–783, Dec., 1901. Paper read before the Siebenbürger Museum-Vereins, Feb. 22, 1901.)—The paper gives measurements, made on a large number of rods of different kinds of hardened steel, of their permanent magnetic moments after magnetisation in fields of different strengths. The magnetic moments are expressed in arbitrary units. The steel having the greatest moment was a nickel-chrome steel, followed, in order of decreasing moments, by chrome steel, nickel steel, tungsten steel, carbon steel, and manganese steel. The magnetic moment and the intensity of magnetisation decreases with the length of the rod. The rods were sent for exhibition to the Paris Exhibition, and measurements made on their return showed a large decrease in moment, from 25 per cent. to 35 per cent. in the case of the nickel and chromium steels, while in the case of the tungsten steel the moment decreased from 53·6 to 1·0. Demagnetising curves are given between the demagnetising field and the moment. The moment could be increased to nearly the same value in the opposite sense. Strong magnetisation of a rod of limonit ($2Fe_2O_3 + 3H_2O$) gave a hardly perceptible moment. G. H. B.

505. *Magnetic Declination and Inclination in France.* **E. Mathias.** (Archives Néerlandaises, 6. pp. 412–429, 1901. Also Comptes Rendus, Nov. 25, 1901.)—The author has already adduced a linear formula to represent the horizontal intensity throughout France in terms of latitude and longitude [see Abstract No. 1130 (1901)]. This was done by taking the region of Toulouse as his normal region, and using, for the rest of France, the data of Moureaux in his Magnetic Report for 1896. In the case of the declination and inclination, however, the corresponding formulæ are more complex, being of the second degree, and containing five or six terms.

The expression for declination is :—

$$\begin{aligned}\Delta D = {} & 0{\cdot}42\,(\Delta\,\text{long.}) + 0{\cdot}17\,(\Delta\,\text{lat.}) + 0{\cdot}00009\,(\Delta\,\text{long.})^2 \\ & + 0{\cdot}000086\,(\Delta\,\text{long.})\,(\Delta\,\text{lat.}) - 0{\cdot}000062\,(\Delta\,\text{lat.})^2\end{aligned}$$

Here ΔD stands for the difference between the declination of any given station and that of Toulouse, in terms of Δ (long.) and Δ (lat.), the differences between the longitudes and latitudes respectively of the two stations. A somewhat similar expression is given for the inclination. Tables are given showing that the formulæ represent facts very closely, both on the coast and inland : thus for more than 300 stations the differences in declination are less than 3′. Disturbed regions are found in various places but they do not affect the general law for the whole country. P. E. S.

REFERENCES.

506. *Circuit-breakers.* **H. Denis.** (Électricien, 22. pp. 359–361, Dec. 7 ; 372–374, Dec. 14 ; and pp. 392–395, Dec. 21, 1901.)—The paper describes some forms of circuit-breakers for use with induction coils, manufactured by Lecarme Frères and Michel. G. H. B.

507. *König's Manometric Flames for Studying Changes in Wave-form of Alternating Currents.* **R. Weber.** (Archives des Sciences, 12. pp. 602–608, Dec., 1901. Paper read before the Société Helvétique des Sciences Naturelles, Aug. 6, 1901, at Zofingue.) This is a paper on the same lines as the one dealt with in Abstract No. 81 (1902).

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

508. *A New Element in Thorium.* **C. Baskerville.** (Chem. News, 84. pp. 179–181, Oct. 11, and pp. 187–189, Oct. 18, 1901. Paper read at the Denver meeting of the American Chemical Society, Aug. 27, 1901.)—Pure thorium, from pure thorium tetrachloride, has an atomic weight of no more than about 223·3. Ordinary pure thorium, from monazite sand, contains a radio-active element whose atomic weight (if it be tetravalent) lies between 260 and 280; carolinium, Cn. A. D.

509. *Thermochemistry of Compounds of Aluminium Chloride with Alkaline Chlorides.* **E. Baud.** (Comptes Rendus, 133. pp. 869–871, Nov. 25, 1901.)—The heat of formation of $Al_2Cl_6.2NaCl$ sol., is 11·8 cal., of the corresponding potassium compound 26·38 cal., of the ammonium compound 26·53 cal. The bodies, $Al_2Cl_6.3NaCl$, $Al_2Cl_6.6NaCl$, and the corresponding potassium compounds—here described for the first time—are in accordance with their heats of formation, very probably definite compounds. D. H. J.

510. *Sulphuric Acid and its Manufacture by the Contact Process.* **R. Knietsch.** (Ber. Deutsch. Chem. Gesell. 34. pp. 4069–4115, Dec. 28, 1901.)—Sulphuric acid is now manufactured on a large scale by the direct combination of sulphur dioxide and oxygen in presence of spongy platinum. The sulphur dioxide is prepared by burning pyrites, but extraordinary care has to be taken to free it from arsenic, which immediately destroys the activity of the platinum. The output of sulphuric anhydride in 1900 amounted to 116,000 tons. The interaction begins at about 200°, and reaches a maximum at about 430°, but is only complete in presence of an excess of oxygen; above 430° decomposition of the sulphur trioxide begins and is complete above 1,000°; the temperature of action is therefore kept below 450°, and in practice 98–99 per cent. of the sulphur dioxide is oxidised. Contrary to all expectation, the absorption of the sulphur trioxide is not readily accomplished by water, but takes place with remarkable readiness when a 96–98 per cent. acid is used; this is in accordance with the fact that the boiling-point of the acid reaches a maximum and the vapour pressure a minimum in an acid containing 98⅓ per cent. H_2SO_4.

A study of the physical properties of the acid shows maxima in the melting-point curve at compositions corresponding to the formulæ $H_2SO_4 + H_2O$, H_2SO_4, and $H_2S_2O_7$, and corresponding minima in the conductivity curve; a minimum conductivity was found by Kohlrausch at 99·74–99·75 per cent. H_2SO_4, but the minimum value now found for acid prepared from pure sulphur trioxide is at 99·9–99·95 per cent., agreeing more exactly with the composition of the monohydrate H_2SO_4. The readiness with which iron is attached by the strong acid corresponds closely with the conductivity of the acid, both reaching a maximum at 12–15 per cent. of free SO_3. The viscosity reaches maxima at concentrations corresponding nearly with the formulæ $H_2SO_4 + H_2O$ and $H_2S_2O_7$, and the capillarity also changes abruptly at the latter point. Points of maximum density occur at 97·66 per cent. H_2SO_4 and at 55 per cent. free SO_3, with a minimum at 99·4 per cent. H_2SO_4. The specific heat of the acid reaches a minimum at about 21 per cent. free SO_3, but the heat of solution rises steadily from 0 per cent. to a maximum at 100 per cent. SO_3.

T. M. L.

511. *Formation of Naturally-occurring Anhydrite, and the Rôle of Time in Chemical Transformations.* **J. H. van't Hoff.** (Archives Néerlandaises, 6. pp. 471–489, 1901.)—The first part of the paper gives a summary of the researches carried out in van't Hoff's laboratory, whereby the difficult question of the transformations of calcium sulphate and its hydrates has been elucidated. The special methods required for the solution of this problem are described in detail. Gypsum, $CaSO_4.2H_2O$, in contact with saturated solution, is transformed into the semihydrate, $CaSO_4\frac{1}{2}H_2O$, at a temperature of 107·2 (pressure = 970 mm.), *i.e.*, we have—

$$107{\cdot}2^\circ C..2CaSO_4.2H_2O \rightleftarrows (CaSO_4)_2.H_2O + 3H_2O.$$

The remarkable fact has been ascertained that the semihydrate obtained under these conditions is, in reality, an unstable or metastable form, for gypsum is converted (in contact with saturated solution) into an *anhydrous* form at a temperature below 100° C., that is to say, the transition-temperature corresponding to the equilibrium

$$CaSO_4 2H_2O \rightleftarrows CaSO_4 + 2H_2O,$$

lies below 100° C., and hence the semihydrate at the temperature of its formation, as given above, tends to decompose as follows :—

$$2(CaSO_4)_2.H_2O = CaSO_4.2H_2O + 3CaSO_4.$$

The *anhydrous* calcium sulphate referred to here is not the natural anhydrite, but a more soluble, and therefore itself unstable, form. This soluble form can be obtained by hydrating ordinary plaster-of-Paris, which is simply the semihydrate, with an excess of water, filtering, drying, and heating at 100° C. As this soluble form is unstable with respect to the insoluble (naturally-occurring) form, it follows that the latter will be produced from gypsum at a still lower temperature. Experiments indicate that this transition-point, in presence of saturated sodium chloride solution, lies about 30° C. This explains fully the occurrence of anhydrite in the natural oceanic deposits studied by van't Hoff. The difficulties encountered in the study of calcium sulphate are due to the slowness with which certain forms are produced and certain equilibria attained. In the second part of the paper van't Hoff is led to a generalisation on this point. *The sluggishness increases as the valency of either the metal or the anionic group increases.* Numerous instances are quoted in support of this view. A very striking instance is the case of thorium sulphate, where the speed of reaction is remarkably small. The same general law is observed to hold in the case of the free non-metallic elements. Thus in the series of elements oxygen, sulphur, phosphorus, carbon, the unstable forms exhibit an increasing degree of "false equilibrium" as the valency increases, *i.e.*, the speed of change into the stable form diminishes. Finally van't Hoff points out that it is this characteristic, exhibited in an eminent degree by carbon, which gives to organic chemistry its peculiar character. If all the essentially unstable isomers, polymers, &c., of organic chemistry were to be eliminated, there would be comparatively few compounds left. [See also Abstract No. 1721 (1901).]

F. G. D.

512. *Formation of Oceanic Salt-deposits. Separation of Kieserite at 25°.* **J. H. van't Hoff, W. Meyerhoffer,** and **N. Smith.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 42. pp. 1034–1044, Oct. 31, 1901.)—The hydrate $MgSO_4.12H_2O$ passes, at 1·8°, into the common hydrate $MgSO_4.7H_2O$, and this, at 48·2°, into the hexahydrate $MgSO_4.6H_2O$. Above a temperature lying between 67° and 68° kieserite, $MgSO_4.H_2O$ is the stable hydrate, but the hydrates $MgSO_4.5H_2O$ and $MgSO_4.4H_2O$ can also exist in a labile condition above 77½° ; the existence of the hydrate $4MgSO_4.5H_2O$ as a hydrate distinct from kieserite is not fully established. Kieserite is also formed at ordinary temperatures by the action of dehydrating agents on the other hydrates. At 25° $MgSO_4.7H_2O$ and $MgSO_4.6H_2O$ are in equilibrium together when in contact with a solution of the composition $1000H_2O$, $62\frac{1}{2}MgSO_4$, $116HNO_3$, the hydrates $MgSO_4.6H_2O$ and $MgSO_4.4H_2O$ are in equilibrium with a solution of the composition $1000H_2O$, $67MgSO_4$, $140\frac{1}{2}HNO_3$, and the hydrate $MgSO_4.6H_2O$ and kieserite are in equilibrium with a solution of the composition $1000H_2O$, $65\frac{1}{2}MgSO_4$, $132HNO_3$. Magnesium chloride has a dehydrating action similar to that of nitric acid, the hydrates $MgSO_4.7H_2O$ and $MgSO_4.6H_2O$ are in equilibrium together at 25° with a saturated solution of common salt containing $1000H_2O$ to $12MgSO_4$, $67\frac{1}{2}MgCl_2$, $4Na_2Cl_2$, the hydrates $MgSO_4.6H_2O$ and $MgSO_4.4H_2O$ with a saturated salt solution containing $1000H_2O$ to $8\frac{1}{2}MgSO_4$, $85MgCl_2$, $1\frac{1}{2}Na_2Cl_2$, and the hydrate $MgSO_4.6H_2O$ and kieserite with a solution containing $1000H_2O$ to $9\frac{1}{2}MgSO_4.79MgCl_2$ and $2\frac{1}{2}Na_2Cl_2$. The conditions of equilibrium are then considered in solutions containing $MgSO_4$, $MgCl_2$, K_2Cl_2, Na_2Cl_2, and lastly in solutions saturated with salt and containing sulphate and chloride of potassium in addition to sulphate and chloride of magnesium. [See further Abstract No. 1538 (1901).] T. M. L.

513. *Production of Optically Active Compounds from Inactive Substances.* **J. B. Cohen** and **C. E. Whiteley.** (Chem. Soc., Journ. 79. and 80. pp. 1305–1312, Dec., 1901.)—This paper describes an attempt to produce a new asymmetric carbonatom in an already active compound from which the originally active group could be subsequently detached, in order to ascertain the influence of the active part of the original molecule on the activity of the new group. The methods adopted were the reduction, bromination, or hydroxylation of esters composed of an unsaturated acid and an active alcohol, and the reduction of a ketonic ester of an active alcohol, the alcohol being afterwards removed by hydrolysis, but in all cases negative results were obtained. Amyl cinnamate and several menthyl esters were examined and their optical properties given. S. R.

514. *Coloration of Crystalline Haloid Salts by means of Potassium or Sodium Vapour.* **G. C. Schmidt.** (Phys. Zeitschr. 3. p. 115, Dec. 15, 1901.)—This coloration, described by Giesel (Ber. Deut. Chem. Gesell., 1897, 156–158), can be readily seen by packing sodium or potassium chloride in a tube of difficultly fusible glass, one end of which is blown out into a bulb in which sodium or potassium is heated to boiling, whilst the other end is connected with an air-pump. When the vapours of the metal come into contact with the salt, the beautiful blue colour of the subchloride makes its appearance. The carbonates of sodium and potassium remains unchanged when submitted to this treatment. T. H. P.

515. *Alloys of Aluminium and Magnesium.* **O. Boudouard.** (Comptes Rendus, 133. pp. 1003–1005, Dec. 9, 1901.)—Three compounds of aluminium and magnesium have been isolated by extracting with various solvents a series of alloys of the two metals in different proportions. $AlMg_2$ forms arborescent crystals and has specific gravity 2·08; AlMg has specific gravity 2·15; Al_4Mg has density 2·58. T. M. L.

516. *Condition of the Silicon in Iron Castings.* **P. Lebeau.** (Comptes Rendus, 133. pp. 1008–1010, Dec. 9, 1901.)—From mixtures of iron, silicon, and copper three definite silicides of iron were isolated, having the formulæ Si_2Fe, SiFe, and $SiFe_2$., Si_2Fe is only formed in presence of a very large excess of silicon, and would never occur in an iron casting. SiFe was also found to be readily dissociable, according to the equation $2SiFe = SiFe_2 + Si$, and was almost entirely decomposed by crystallising from silver, *i.e.*, by dissolving in silver and extracting the silver with nitric acid; it would not therefore exist in presence of an excess of iron. $SiFe_2$, on the other hand, is exceedingly stable, and can be recovered entirely unchanged after crystallising from silver; it is therefore probable that the whole of the silicon in iron castings is in this form. SiFe is non-magnetic, but $SiFe_2$ is magnetic.

T. M. L.

517. *Liquid Nitrogen Peroxide as a Solvent.* **P. F. Frankland** and **R. C. Farmer.** (Chem. Soc., Journ. 79. and 80. pp. 1356–1373, Dec., 1901.)—When used as a solvent, nitrogen peroxide shows an unexpected resemblance to the common organic solvents, such as benzene and ether, rather than to the inorganic solvents. Thus in no single instance were inorganic salts found to be soluble in it, whilst organic compounds dissolved freely; in most cases the solubility of the substances in liquid nitrogen peroxide resembled their solubility in ether, but a few substances insoluble in ether were found to dissolve in liquid nitrogen peroxide. When dry and free from lower oxides of nitrogen, the peroxide is remarkably inert, cane-sugar being soluble without decomposition; hydroxy- and amino-compounds are, however, usually attached. Dry liquid nitrogen peroxide is a non-conductor; when no special precautions were taken to remove all traces of water, the liquid had a specific conductivity $0{\cdot}1$ to $0{\cdot}2 \times 10^{-6}$, the minimum value for water distilled in air being $0{\cdot}65 \times 10^{-6}$; but by adding phosphorous pentoxide the conductivity was reduced so far as to be unmeasurable. When mixed with 2 per cent. of water the conductivity is as great as that of $N/100\ HNO_3$, but dry solutions in nitrogen peroxide of hydrogen chloride and of a number of organic acids were found to be non-conductors. In the case of eight neutral substances the molecular elevation of the boiling-point was found to be 13·7° C. for 1 gram-mol. of the substance per 100 grams of solvent. Benzoic acid, the three toluic acids, acetic, tribromacetic and trichlorobutyric acids were found to be associated more or less completely to double molecules—a mode of behaviour which is characteristic also of solutions in benzene of organic acids; dinitrophenol and picric acid gave normal values for the molecular weight.

T. M. L.

518. *Solubility of Silver Bromide and Silver Iodide in Water.* **F. Kohlrausch** and **F. Dolezalek.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 41. pp. 1018–1023, Oct. 24, 1901.)—The determination of the solubility of silver bromide and iodide by means of conductivity measurements presents unusual difficulties, owing to the extraordinary smallness of the quantities measured; thus the effect of breathing close to the conductivity vessel raises the conductivity of the water to an extent as great as that produced by saturation

with silver bromide, and forty times as great as that produced with silver iodide. All the previous determinations that have been made have given results many times greater than those now recorded. Pairs of experiments with water saturated with silver bromide, starting from higher and from lower temperatures, gave an increase of conductivity of $0{\cdot}075 \times 10^{-6}$ units, at 21·1°, corresponding to the dissolution of $0{\cdot}57 \times 10^{-6}$ gram-equivalents or 0·107 mg. AgBr per litre. In the case of silver iodide it was found that satisfactory measurements could best be made by pouring the water on to silver iodide and determining its conductivity before and after it had been saturated by shaking. The increase in conductivity was only $0{\cdot}0020 \times 10^{-6}$ units at 20·8°, corresponding to the dissolution of $0{\cdot}015 \times 10^{-6}$ gram-equivalents or 0·0035 mg. per litre. The solubility of silver bromide and iodide has also been deduced in accordance with Nernst's law from the e.m.f. of concentration cells, and, although the values obtained by different observers differ considerably, they are all of the same order of magnitude as those now recorded, and values which are practically identical with these have been obtained by two observers in the case of each of the two silver haloids. T. M. L.

519. *Dilution Constant of Saline Solutions.* **A. Colson.** (Comptes Rendus, 133. pp. 1207–1209, Dec. 23, 1901.)—The author's previous experiments [see Abstract No. 120 (1902)] appeared to indicate that the critical temperature shown to exist in the case of some salts, at which there is no thermal change on dilution, depends only on the nature of the solvent and the dissolved substance; and not at all on the state of dilution. The author confirms this by experiments on solutions of common salt, varying in concentration from a completely saturated solution to a tenth of that amount, the fixed temperature being now determined by the following method: 100 cub. cm. of a saturated solution of the salt are sealed in a bulb and placed in a calorimeter containing 400 cub. cm. of distilled water and surrounded by a bath of constant temperature. The bulb is then broken, and the change of temperature noted. When the alterations of temperature are taken as ordinates, and the temperatures of the bath as abscissæ; the resulting curve is nearly rectilinear, and cuts the axis of abscissæ at the desired point. This temperature is 52° C. for NaCl; 64°·5 C. for KCl; 116° C. for $NaNO_3$; 122° C. for KNO_3. The two last values are obtained by interpolation. W. C. B.

520. *Plaitpoint Curves in Ternary Systems.* **F. A. H. Schreinemakers.** (Archives Néerlandaises, 6. pp. 170–192, 1901.)—Four curves are discussed: (1) For critical fluids of the first order at constant pressure; (2) for critical fluids of the first order at constant temperature; (3) for critical fluids of the first order under their own vapour pressure; (4) for critical fluids of the second order. When, at definite temperature and pressure, two plaitpoints occur on the binodal curve, there corresponds to each a critical solution, called a critical fluid of the first order. When, for a change of temperature or pressure, the binodal curve diminishes and the solutions of the first order have more nearly the same composition, the plaitpoints ultimately coincide in a double plaitpoint, and the corresponding solution is called a critical solution of the second order. It is pointed out that a critical solution of the second order may also arise, as previously obtained experimentally, from the occurrence of two binodal curves with a plaitpoint on each, which ultimately coincide as pressure and temperature are changed. The various analytical conditions

for the critical fluids, and the differential equations of the curves, are developed. In particular the equation—

$$\frac{dT}{dx} = \frac{\frac{\partial t}{\partial x} - \frac{s^2}{RT}}{\frac{\partial^2 \eta}{\partial y^2}}$$

is found to determine whether the temperature, at which two fluid layers become identical, rises or falls when a third component is added. W. E. T.

521. *Formation of Ozone.* **A. Chassy.** (Comptes Rendus, 133. pp. 789–791, Nov. 11, 1901.)—The author gives the results of a study of the proportions of ozone formed on passing an electric discharge for varying times through a definite mass of oxygen, the current being meanwhile maintained constant. The increase in the proportion of ozone follows the same law, no matter what the intensity of current employed. Further, a feeble current can always produce the same effect as one more intense, provided its time of action be sufficiently great, or, if an apparatus for continuous production be used, provided the flow of gas is sufficiently slow. The following numbers are for 20°, the unit of time being that necessary for the transformation into ozone of 0·5 per cent of the oxygen :—

Time.	Quantity of Ozone.	Time.	Quantity of Ozone.
1	5	10	31·5
2	9·1	12	34·5
3	12·7	14	37·4
4	16·1	20	44
5	19·2	36	54
6	22·2	60	64·5
7	25	90	70·5
8	27·2	120	73

The curve representing these results is asymptotic to the time axis; the quantity of ozone tends towards a limiting value which depends only on the temperature and not on the current intensity, but which is difficult to determine accurately. It is seen from the above table that to obtain oxygen containing 70 parts per 1,000 of ozone costs ninety times as much as to prepare oxygen with 5 parts of ozone per 1,000. Considering only the expenditure of electrical energy, it is economical to only feebly ozonise the oxygen and to promote the active circulation of the gas. T. H. P.

522. *Specific Inductive Capacity of Solvents.* **H. Schlundt.** (Journ. Phys. Chem. 5. pp. 503–526, Oct., 1901. Printed in full in the Univ. Wisconsin, Bull., Science Series, 1901.)—In 1893 Nernst [Gott. Nach. No. 12 (1893), also Zeit. Phys. Chem. 13,531 (1894)], gave the rule that, other things being equal, the greater the specific inductive capacity of a medium the greater is its dissociating power. J. J. Thomson also pointed this out, saying that, if the forces between the atoms are electrical, then the effect of surrounding the molecules of a substance by a medium possessing very high specific inductive capacity like water would be to dissociate them. The following important tables are given :—

Name.	Formula.	Boiling Point.	Atmospheric Pressure mm. of Hg.	Temperature (Centigrade).	Specific Inductive Capacity.
Methylamine	CH_3NH_2	—	—	<10·5	21
Ethylamine	$C_2H_5NH_2$	<17·5	752	6·17	21
Isopropylamine	$(CH_3)_2CHNH_2$	36	750·5	5·45	20
Butylamine (*n*)	$C_4H_9NH_2$	76–77	740·0	5·30	21
Isobutylamine	$(CH_3)_2CHCH_2NH_2$	68	745·2	4·43	21
Amylamine	$C_5H_{11}NH_2$	94–95	740·4	4·50	22
Diethylamine	$(C_2H_5)_2NH$	54·5	733·4	3·58	21
Dipropylamine	$(C_3H_7)_2NH$	108-108·5	745·5	2·90	22
Diisobutylamine	$[(CH_3)_2CHCH_2]_2NH$	134.5	735·0	2·65	22
Trimethylamine	$(CH_3)_3N$	<8	750	2·95	4
Aniline	$C_6H_5NH_2$	179·4	741	7·2	18·5
Toluidine (*o*)	$C_6H_4<\begin{matrix}CH_3\\NH_2(o)\end{matrix}$	194·5	738·0	5·93	20
Toluidine (*m*)	$C_6H_4<\begin{matrix}CH_3\\NH_2(m)\end{matrix}$	194·2	738·2	5·95	20
Xylidine 1 : 3 : 4	$C_6H_5\begin{matrix}/CH_3\ 1\\-CH_3\ 3\\\backslash NH_2\ 4\end{matrix}$	209·5	737·0	4·90	20
Monomethylaniline	$C_6H_5NHCH_3$	189·4	740·5	5·8	20
Dimethylaniline	$C_6H_5N(CH_3)_2$	191·5	735·0	5·07	20
Dibenzylamine	$(C_7H_7)_2NH$	200	40·0	3·55	20
Nitromethane	CH_3NO_2	99·9	738·4	40·4	19
Nitroethane	$C_2H_5NO_2$	110·5	738·3	29·5	18
Methyl nitrate	CH_3NO_3	64·4	730·2	23·5	18
Ethyl nitrate	$C_2H_5NO_3$	86·1	729·4	18·3	18
Propyl nitrate	$C_3H_7NO_3$	108·5	738·5	13·9	18
Isobutyl nitrate	$(CH_3)_2CHCH_2NO_3$	120·0	738·2	11·7	19
Isopropyl nitrite	$(CH_3)_2CHNO_2$	—	—	11·5 ?	18
Ethyl urethane	$CO(NH_2)(OC_2H_5)$	—	—	13·6	60
Ethyl urethane (solid)	—	—	—	3·18	23
a-Picoline	$(C_5H_4N.CH_3(a)$	128·5–129·5	736	9·8	20
Piperidine	$C_5H_{11}N$	105·5–107	745	5·8	20
Carbon dichloride	C_2Cl_4	118	726·5	2·46	21
Amylsulphydrate	$C_5H_{11}SH$	116·5	752	4·35	22
Ethylene cyanide	$C_2H_4(CN)_2$	168	28	61·2	60
„ „ (solid)	„	—	—	65·3	23
a-Naphthonitrile	$(C_{10}H_7CN(a)$	—	—	16·0	70
„ (liquid)	„	—	—	17·9	42
„ „	„	—	—	19·2	22
„ (solid)	„	—	—	6·3 ?	21
β-Naphthonitrile	$C_{10}H_7CN(\beta)$	190	35	16·9	70
„ (solid)	„	—	—	4·3	22
Mandelic nitrile	$C_6H_5CH<\begin{matrix}OH\\CN\end{matrix}$	94	50	17·82	23
Phosphorus trichloride	PCl_3	74·1	740	3·36	22
Arsenic „	$AsCl_3$	127–128	740	12·35	21
Antimony „	$SbCl_3$	—	—	33·2	75
„ „ (solid)	„	—	—	5·4	18
Antimony pentachloride	$SbCl_5$	—	—	3·78	21·5
Stannic chloride	$SnCl_4$	117·5	750	3·2	22
Sulphur monochloride	S_2Cl_2	136·2	738	4·8	22
Sulphur dioxide	SO_2	—	—	12·35	22
Sulphur trioxide	SO_3	—	—	3·56	21
„ „ (solid)	„	—	—	3·64	19
Sulphuryl chloride	SO_2Cl_2	68·4	740·2	9·15	22
Thionyl	$SOCl_2$	76·8	751·3	9·05	22
Phosphorus oxychloride	$POCl_3$	105·1	739·2	13·9	22
Cyanogen	$(CN)_2$	—	—	2·52	23
Bromine	Br	—	—	3·18	23
Iodine (solid)	I	—	—	10·3 ?	23

The principal points in the paper are :—

(1) The values of the dielectric constants for the homologous series of compounds examined decrease with increase of molecular weight. (2) The introduction of the cyanogen group in a compound causes a marked increase in the value of the dielectric constant. In this respect the cyanogen radical produces a greater effect than all other radicals which have hitherto been systematically studied. (3) The cyanogen (CN), amido (NH_2), or nitric acid (NO_3) radicals, when present in compound, do not cause anomalous absorption, which Drude found for the hydroxyl (OH) group. (4) A number of new examples are given which follow the Nernst-Thomson rule. (5) Some striking exceptions to the Nernst-Thomson rule are pointed out, from which it has been argued that the rule is inadequate. The exceptions indicate that the nature of the solvent, as well as the dissolved substance, are of primary importance in determining whether a solution will conduct electricity. (6) Obach's law holds only approximately for the nitriles. [See also Abstract No. 1358 (1901).] M. O'G.

523. *Effect of Low Temperatures on Voltaic Cells.* **L. Bleekrode.** (Archives Néerlandaises, 6. pp. 448–454, 1901.)—The author placed cells (a copper oxide cell, and a secondary cell) in a bath of solid carbon dioxide dissolved in acetone. Values of the e.m.f. and internal resistance are given for various temperatures down to − 65°, apparently without the condition of the cell being constant. The general effect of lowering of temperature is to diminish the e.m.f. and to raise the internal resistance. W. R. C.

524. *Influence of Temperature on Conductivity of Solutions and Mobility of Ions in Water.* **F. Kohlrausch.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 42. pp. 1026–1033, Oct. 31, 1901.)—The influence of temperature on the electrical conductivity of solutions may be represented by the formula—

$$\kappa_t = \kappa_{18}\left[1 + \alpha(t-18) + \beta(t-18)^2\right].$$

From observations in the case of dilute solutions the temperature coefficients may be deduced for infinitely dilute solutions. These are shown in the following table :—

Solution.	α	β	Solution.	α	β
HNO_3	0·0163	− 0·000016	K_2SO_4	0·0222	+ 0·000077
HCl	0·0164	− 0·000015	PbN_2O_6	0·0224	+ 0·000078
H_2SO_4	0·0165	− 0·000017	$BaCl_2$	0·0225	+ 0·000083
H_3PO_4	0·0169	− 0·000001	NaCl	0·0226	+ 0·000084
KOH	0·0190	+ 0·000032	$SrSO_4$	0·0228	+ 0·000084
KNO_3	0·0210	+ 0·000062	Na_2SO_4	0·0233	+ 0·000097
KI	0·0212	+ 0·000058	$MgSo_4$	0·0238	+ 0·000095
$AgNO_3$	0·0216	+ 0·000067	$NaHC_4H_4O_4$	0·0241	+ 0·000109
KCl	0·0217	+ 0·000067	NaF	0·0242	+ 0·000102
NH_4Cl	0·0219	+ 0·000068	$NaC_2H_3O_2$	0·0242	+ 0·000110
$NaNO_3$	0·0220	+ 0·000075	$NaC_5H_9O_2$	0·0243	+ 0·000111
BaN_2O_6	0·0220	+ 0·000075	Na_2CO_3	0·0262	+ 0·000151
KF	0·0222	+ 0·000079			

As α increases β is seen to increase regularly from a small negative value in the case of the acids, to a large positive value, and the relationship between the constants may be expressed, within the limits of experimental error, by the formula $\beta = 0·0163(\alpha - 0·0174)$. The change of conductivity with temperature may then be expressed by means of a single arbitrary constant, since β can be calculated when α is known. When $\alpha = 0·0174$ then $\beta = 0$ and the conductivity-temperature curve is a straight line. The two constants in the above formula are nearly equal, and the experimental results may be represented with only slightly less accuracy by the formula $\beta = 0·0177\ (\alpha - 0·0177)$. According to this formula, the conductivity of all salts would cease at −89° C., whilst the more accurate formula gives a variation in the "conductivity zero" of ±2° according to the nature of the salt. The frictional constant η of water can be represented by the formula $\eta = 2·989\ (t + 88·5)^{-1·40}$ c.g.s. units; it would therefore appear that at −89° the water would entirely lose its fluidity, apart from crystallisation, and a ready explanation of the "conductivity zero" of aqueous solutions is thus afforded.

In the case of incompletely dissociated solutions the relationship between β and α is less exact, but has a remarkably wide range; a fair agreement appears in the extreme case of $KHSO_4$ (5 per cent.) where α is only 0·0095, and also in the case of sulphuric acid where α changes from 0·0125 in a 5 per cent. solution to 0·0345 in an 84·5 per cent. solution (H_2SO_4, H_2O) whilst β changes in the normal way from −0·000052 to +0·000297. Knowing the mobility of the ions at 18°, and the transportation-value of one salt at some other temperature, the temperature-coefficients of the separate ions can be deduced, and are given in the following table:—

Ion.	l_{18}	α	β	Ion.	l_{18}	α	β
H	318	0·0154	−0·000033	F	45·5	0·0232	+0·000094
OH	174	0·0179	+0·000008	IO_3	33·9	0·0233	+0·000096
NO_3	61·8	0·0203	+0·000047	$C_2H_3O_2$	34	0·0236	+0·000101
I	66·4	0·0206	+0·000052	$\frac{1}{2}$Ba	57	0·0239	+0·000106
ClO_3	57	0·0207	+0·000054	$\frac{1}{2}$Cu	49	0·0240	+0·000107
Cl	65·4	0·0215	+0·000067	$\frac{1}{2}$Pb	61·5	0·0244	+0·000114
Rb	67·9	0·0217	+0·000069	Na	43·5	0·0245	+0·000116
K	64·7	0·0220	+0·000075	$\frac{1}{2}$Mg	46·0	0·0255	+0·000132
NH_4	63·7	0·0223	+0·000079	$\frac{1}{2}$Zn	46	0·0256	+0·000133
$\frac{1}{2}SO_4$	69	0·0226	+0·000084	Li	33·4	0·0261	+0·000143
Ag	54·7	0·0231	+0·000093	$\frac{1}{2}CO_3$	(70)	(0·0269)	+(0·000155)
$\frac{1}{2}$Sr	53	0·0231	+0·000093				

Amongst the univalent kations H, Rb, K, NH_4, Ag, Na, Li, the simple temperature coefficient α is itself dependent in a regular way upon the mobility of the ion, and can be calculated within the limits of experimental error from the formula $\alpha - 0·0065 = 0·0683 \left(\frac{1}{l}\right)^{0·3515}$; for these substances, therefore, one independent constant only is needed to determine the mobility at all temperatures. T. M. L.

525. *Transport of Liquids by Electric Current.* **E. van der Ven.** (Archives Néerlandaises, 6. pp. 127–132, 1901.)—In the papers by G. Wiedemann and C. Freund on this subject (Ann. d. Physik, 163. p. 321, and 243. p. 44) there is no reference to the part played by hydrostatic pressure, due to the continuously increasing difference between the densities of the solution on the two sides of the porous membrane, the solution in the division containing the kathode becoming the lighter. The author used a solution of 10 parts crystallised sulphate of copper to 100 of distilled water: its density was

1·064. Using a 2-volt accumulator, he found that the quantities of liquid passing steadily increased, while the strength of the current fell off somewhat. Making a control experiment with a hydrostatic pressure corresponding to the difference of density between the two parts of the solution he found, taking into account the gradual divergence between the two densities, that out of say 33 grms. of liquid driven through by the current, say 8 were driven by the hydrostatic pressure. A. D.

526. *Determination of Ionic Velocities in Aqueous Solutions.* **R. Abegg.** (Phys. Zeitschr. 3. pp. 124–125, Dec. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg, 1901.)—The method of B. D. Steele [see Abstract No. 1555 (1901)], whose theory had been developed by F. Kohlrausch and H. Weber, gives good results for simple salts like the alkali haloids, but proves less satisfactory in cases where we have reason to assume the presence of complex ions. The stability of the boundary faces is influenced by various circumstances, which Nernst's theory of liquid galvanic couples seems best able to explain. The author agrees with Steele. H. B.

527. *Electrolytic Reduction of Nitrourea.* **G. W. F. Holroyd.** (Chem. Soc., Journ. 79. and 80. pp. 1326–1331, Dec., 1901.)—Semicarbazide was obtained by electrolysing nitrourea in an aqueous solution of ammonium chloride as electrolyte, using electrodes of varying sizes and of wrought iron, fine or platinum. After interrupting the current the contents of the cell are filtered, the filtrate acidified with HCl, and benzaldehyde added, forming benzylidenesemicarbazide. A table is given showing yield of carbazide under varying conditions of temperature, size, and nature of electrodes, and density of current. With zinc poles an alternating current was employed, the alternator being a modification of a form suggested by Mr. A. G. Vernon-Harcourt some years ago, consisting of a flask connected with a U-tube about half full of mercury. After setting the mercury in oscillation, the movement continues so long as the flask is heated, and thus makes and breaks contact. S. R.

528. *Reduction of Alumina by Calcium Carbide.* **S. A. Tucker** and **H. R. Moody.** (Soc. Chem. Ind., Journ. 20. pp. 970–971, Oct., 1901.)—A charge consisting of 100 grams alumina, 112 grams lime, and 125 grams of coke, was heated for ten minutes in an electric furnace at 150 amperes and 70 volts. In addition to aluminium carbide, which was thus formed, there were also found buttons of metallic aluminium, containing, upon analysis, 99 per cent. of metallic aluminium, the rest consisting of iron and mechanically enclosed carbon.

$$Al_2O_3 + CaC_2 = 2Al + 2CO + CaO.$$

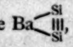
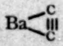
A table, containing the results obtained under varying conditions, is then given. The conclusions drawn from this series of experiments are as follows: (1) Aluminium oxide is not reduced by carbon to any appreciable extent, even when both are heated to the extremely high temperature of the electric arc. (2) The addition of lime and the necessary excess of carbon forms an alkaline earth carbide, which is in turn decomposed, and being a body exothermic on decomposition, it yields up a large number of calories, and thus raises the temperature to such a degree that reduction of the oxide takes place to an appreciable extent. (3) The carbide may be made in a separate fusion, and added to the alumina, with or without carbon, but the presence of some carbon seems to increase the yield of the metal. The production of the carbide in a separate fusion would, however, be condemned on economic grounds. (4) As regards time, anything over twelve or fifteen minutes is prejudicial to good results, and converts the reduced metal to carbide in amounts increasing directly as the excess over the maximum admissible time increases. (5) Aluminium carbide was found to be produced by the metal, and not the reverse. The whole subject may be summed up as follows: The results obtained favour the use of high amperage and voltage for not more than fifteen minutes. The presence of both carbon and a carbide of an alkaline earth is required. Air should be excluded. Finally, the amount of alumina should be considerably in excess of the theoretical amount of coke.

O. J. S.

529. *Production of Ethylene from Inorganic Sources.* **S. A. Tucker** and **H. R. Moody.** (Soc. Chem. Ind., Journ. 20. pp. 971–972, Oct., 1901.)—The object of the authors' experiments was the production of electric furnace products, such as combinations of carbides, or carbides and silicides, which, when treated with water or dilute acids, would, either directly or by interaction, give off gases differing from the gases when any of these carbides were employed alone. They thought it possible thus to produce ethylene.

As calcium carbide yields C_2H_2, and aluminium carbide CH_4, the authors reasoned that these two carbides, produced simultaneously, and submitted to the action of water, might yield ethylene by interaction in the nascent state. Twelve fusions, carried out under varying conditions, yielded negative results, the gases evolved only consisting of CH_4 and C_2H_2.

Mixed carbides were abandoned in lieu of mixed carbides and silicides.

Barium silicide  $\mathrm{Ba}<\begin{array}{c}\mathrm{Si}\\ ||| \\ \mathrm{Si}\end{array}$, produced simultaneously with  $\mathrm{Ba}<\begin{array}{c}\mathrm{C}\\ ||| \\ \mathrm{C}\end{array}$ in the electric furnace, seemed the most likely bodies to produce, as a secondary product, ethylene. A mixture of 100 grms. witherite, 60 grms. of silica, and 43 grms. of coke, added to a carbide charge of 150 grms. of witherite and 25 grms. of coke, and heated by a current of 150 amperes and 60 volts for seven minutes, yielded a blackish mass, which on treatment with warm water gave off a gas containing from 8 to 15 per cent. of ethylene. On increasing the carbide in the mixture, the yield of ethylene dropped to 2 per cent.

Strontium and calcium employed in lieu of barium, gave rather poorer yields.

O. J. S.

530. *Electrolytic Bleaching Apparatus.* **L. Tailfer.** (Ind. Électrochim. 5. pp. 45–48, 1901.)—The author, after enumerating the disadvantages attending the use of the cells and apparatus for production of bleaching solutions at present in use, describes an improved form devised by himself. In this cell the positive and negative electrodes are formed of platinum wire, and are carried on an ebonite bar or rod fixed at the bottom of the cell. The wires are wound upon this rod as two parallel-spirals, and the distance separating the anode and kathode wires is therefore small.

The cell or tank contains a large number of these ebonite bars, each carrying a positive and negative electrode, and the goods to be bleached are passed through the liquid in the upper portion of the tank while the current is being passed through the spiral electrodes. Two different forms of apparatus are shown in the diagrams accompanying this article, intended for use with hank-yarn and piece-goods respectively. The electrolyte, containing 15–20 grammes salt per litre, can only be used for a certain number of hours, and is then discharged and a fresh solution charged into the electrolytic tank.

No tests or details of cost are given by the author. Electrolytic bleaching is stated to be little used in France. J. B. C. K.

531. *New Form of Diaphragm Cell for the Electrolytic Production of Alkalies and Chlorine.* **J. B. C. Kershaw.** (Electrician, 48. pp. 125–126, Nov. 15, 1901.)—Different types of cells are touched upon by the author, who then proceeds to the subject of the article—the diaphragm cell patented by Moore, Allen, Ridlon & Quincy. In many respects it closely resembles the Hargreaves-Bird type of cell, and should the Moore-Allen cell become of industrial importance the question of patent validity is almost certain to arise. The advantages claimed for the Moore-Allen are: that no steam is required to remove the sodium or potassium hydrate from the kathode, that a fairly concentrated solution is obtained containing little undecomposed salt, and that the design and structure of the cell are simplified by dispensing with an enclosed kathode department. The author is doubtful whether the second advantage claimed can be substantiated by the results of actual trial, and concludes by remarking that under the conditions described in the patent specification the economic production of caustic alkali by this cell is impossible. O. J. S.

532. *Electrolytic Recovery of Tin from Tin Scrap.* **F. Gelstharp.** (Electrochemist, 1. pp. 276–278, Dec., 1901.)—The process described in this illustrated article is protected by Patent No. 2282 of 1901. The process has been submitted to practical trial at Manchester, and 60 tons of waste tin-cuttings have been dealt with by the experimental plant. The dynamo used is a two-pole machine, generating 1,500 amperes at 5 volts. Only one to two volts are required for working the process. The stripping tanks are of wood 5·0 × 1·8 × 3·6 feet deep. Tinned sheet-iron kathodes 5·0 × 3·0 feet are fixed 2 inches from each side of the vat. Wooden crates, 56 × 7 × 36 inches deep, hold 56 lbs. of cuttings when fully charged, and rest on supports 6 inches high in the bottom of each vat. Copper conductor bars, dipping into mercury, make electrical contact with the positive pole of the dynamo. Projecting ends of scrap from the crates are twisted round these. The electrolyte is a 1·25 per cent. solution of commercial hydrochloric acid, free from arsenic, and containing a small percentage of sulphuric acid. This addition is made to precipitate any lead alloyed with the tin, as lead sulphate.

A crate of 56 lbs. of cuttings can be stripped in half an hour with a current of 15 amperes per square foot density, and an e.m.f. of 1 to 2 volts. The tin is deposited at the kathodes in spongy form. It is removed at intervals by scraping, and collecting, as it floats on the surface of the electrolyte. This tin sponge is washed, submitted to mechanical pressure, and smelted in a small reverbatory furnace. If preferred, the spongy tin can be used as anode in a second depositing vat, and tin crystals obtained by electrodisposition.

The crates containing the stripped cuttings are immersed in water, and their charges are then tipped into tanks containing brown oil of vitrol. Solution of the iron occurs with heat, and a neutral solution of ferrous sulphate results. From this, crystalline ferrous sulphate is obtained on standing. The electrolyte used in the depositing vats loses its strength on continued use, and fresh acid must be added every fourteen days. Zinc and ferrous chloride, although present with the stannous chloride, are not decomposed by currents of less than 2 volts e.m.f. J. B. C. K.

533. *Electrolysis of Copper Solutions.* **A. Fischer.** (Elektrochem. Zeitschr. 8. pp. 192–193, Dec., 1901.)—The author discusses the composition of electrolytic cyanide baths for depositing bright coatings of copper on iron and zinc plates. He recommends, as giving excellent results, a bath described by Von Pfanhauser (Elecktroplattierung, Galvanoplastik. 4 Aufl. S. 332), containing sodium hydrogen sulphite and normal sodium carbonate. These two salts react in the solution, producing normal sodium sulphite and carbonic acid, so the author recommends a modified bath, in which the chief alteration is the substitution of normal sodium sulphite, for the acid salt and normal carbonate. [See also Abstract No. 143 (1902).] W. C. B.

534. *Aluminium.* **E. Wilson.** (Soc. Arts, Journ. 50. pp. 54–62, Dec. 13, 1901.) — Heroult's cell consists of a square iron or steel box lined with carbon, at the bottom of which is a cast-iron plate connected with the negative pole of the dynamo. The positive pole of the dynamo is connected to a number of carbon rods suspended from overhead, and capable of vertical adjustment. The cell is filled with cryolite, which becomes molten by the passage of the electric current, and then the powdered alumina is fed in continuously as long as the operation proceeds. The potential difference between the terminals of each cell is from 3 to 5 volts, and the current overcomes the chemical affinity of the aluminium oxide, besides heating the electrolyte. The current density is about 700 amperes per square foot of kathode surface, and the working temperature varies from 750° to 850° C. The British Aluminium Company give 1 to 1½ lbs. of aluminium as the quantity obtained per twenty-four e.h.p.-hours. The author gives a series of tests on light alloys, points out the utility of bare aluminium for switchboards, for switches where the inertia of the moving part is important, gives details of the Cowper-Coles and other methods of welding, and suggests the use of aluminium for roofing houses. [See also Abstract No. 961 (1898).]
M. O'G.

REFERENCES.

535. *Radium.* **W. Marckwald.** (Chem. News, 84. pp. 190–191, Oct. 18, 1901.)—A description is given of a method of separating barium out by fractional crystallisation, leaving radio-active radium in more concentrated solution. A. D.

536. *Metals as Fuel.* **W. Roberts-Austen.** (Nature, 64. pp. 360–364, Aug. 8, 1901. Paper read before the Royal Institution, Feb. 22, 1901.)—The author discusses the heat obtainable by the oxidation of metals, and practical results obtained therefrom, more particularly the Goldschmidt process. W. R. C.

537. *The Chemical Significance of Electrical Methods and Theories.* **W. Nernst.** (Phys. Zeitschr. 3. pp. 63–70, Nov. 15, 1901.)—Paper read before the 73 Naturforscherversammlung at Hamburg.

538. *The Phase-Law of Gibbs.* **C. H. Wind.** (Archives Néerlandaises, 4. pp. 323–331, 1901.)—This is a paper on the same lines as that referred to in Abstract No. 677 (1900).

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

539. *Bursting of Small Cast-iron Flywheels.* **C. H. Benjamin.** (Mech. Eng. 8. pp. 856–858, Dec. 28, 1901. Paper read before the American Society of Mechanical Engineers, Dec., 1901.)—A description is given, with tables and photographs, of the results of the bursting, by rapid rotation, of some 16 cast-iron flywheels, each 2 feet in diameter. Examples of the results are given below:—

Description of Wheel.	Bursting Speed.		Centrifugal Tension.	
	Revs. per Min.	Feet per Sec.	Pounds per sq. inch.	Total on Rim.
Solid cast-iron rim, 6 arms	3,700	387	14,980	59,000
Rim with 2 flanged joints, 6 arms	1,850	193·6	3,750	14,000
Solid cast-iron rim, 24 steel spokes	4,050	424	17,970	44,000

H. R. C.

540. *Steam Calorimetry.* **C. L. Hubbard.** (Amer. Electn. 13. p. 591, Dec., 1901; and 14. pp. 34–35, Jan., 1902.)—The first paper describes the separator calorimeter which is used for ascertaining the percentage of moisture, over saturation, which is carried by steam from a boiler. The calorimeter consists of a separator chamber which is formed by two concentric pipes, the inner and smaller one projecting some distance into the outer one, and being perforated with a number of holes about $\frac{1}{8}$ inch diameter at its lower end. Above the perforations the branch from the outer barrel leads to a condenser, and in the branch pipe there is a diaphragm having in its centre a hole of $\frac{1}{16}$ inch diameter. A gauge glass to show the level of water in the barrel of the separator, which is closed by a drip-cock at the bottom, a branch pipe to the boiler, and one for a steam gauge complete the apparatus. When in use the sudden change of direction and velocity causes the steam to deposit the carried moisture in the barrel, and dry steam passes on through the diaphragm. It may be passed through a second calorimeter in series in order to measure the heat lost by radiation, but in event the dry steam is condensed and measured, and the water collected in the separator being also measured, the percentage of moisture is easily obtained from the formulæ: $x = (W + R)/(W + w)$ and $m = 1 - x = (w - R)/(W + w)$, in which $x =$ the quality of the steam; $m =$ the proportion of moisture in the steam tested; $W =$ the weight of dry steam discharged at the exhaust orifice; $w =$ the weight of water drawn from the calorimeter; $R =$ the weight of steam condensed by radiation. The throttling calorimeter can be used when the percentage of moisture in steam is less than 3 per cent., but as it acts on the principle of throttling by wire-drawing so that the superheating effect of this throttling may be utilised, a large amount of moisture would prevent any superheating effect being realised. Steam from the steam-pipe is

admitted to the calorimeter chamber by a ½-inch pipe having a stopcock and throttling orifice of $\frac{1}{16}$ inch diameter. The temperature of the steam in this chamber and its pressure are both carefully taken, the pressure in the main steam-pipe being also noted. The equation for the use of this calorimeter is obtained as follows: The heat in 1 lb. of high pressure dry steam is $xL + h = H_h$, in which x = the quality of the steam, L = the latent heat of evaporation at supply pressure, and h = heat in the water at the same temperature. After reaching the calorimeter chamber the heat in the steam is what is due to its reduced pressure plus that due to its superheat, thus:—

$$H_c + 0{\cdot}48(T_1 - T_c),$$

in which H_c = the total heat in 1 lb. dry steam at calorimeter pressure, T_1 = the temperature indicated by calorimeter thermometer; T_c = the temperature of ordinary dry steam at the calorimeter pressure. As no heat is imported from an external source the total heat units in 1 lb. steam in the calorimeter cannot have increased, hence—

$$H_c + 0{\cdot}48(T_1 - T_c) = xL + h;$$

wherefore—

$$x = \left\{H_c - h + 0{\cdot}48(T_1 - T_c)\right\} + L.$$

F. J. R.

541. *The Use of Zinc in Boilers.* **R. A. Douglass.** (Amer. Electn. 13. pp. 572–573, Dec., 1901.)—This is a practical paper directing attention to the limits to the usefulness of zinc in boilers, and giving some hints as to its application. The action being partly galvanic, the connections between zinc and boiler-plates should be carefully made. Cast-iron fittings in the neighbourhood of zinc sometimes become converted into a soft, almost spongy, condition, and therefore need extra care when in such a position. F. J. R.

542. *Heat-producing Power of Fuel.* **A. Adams.** (Soc. Chem. Ind., Journ. 20. pp. 972–974, Oct.; Discussion, pp. 1084–1085, Nov., 1901.)—The work of Dixon and others, in investigating the behaviour of the carbon gases, has caused attention to be directed to the question of the presence of moisture as affecting their formation. The present experiments show that in determinations of the calorific power of fuel by either Lewis Thompson's or William Thomson's calorimeter, errors have been hitherto neglected, which were due to moisture carried by the escaping gases and to incomplete combustion. By introducing to the fuel specimen a stream of oxygen saturated with moisture, both of these errors are greatly reduced if not wholly prevented. The results of three careful experiments, two with oxygen saturated with water vapour, and one with oxygen direct from a steel bottle, are given—the temperatures and radiation errors having been determined by a Geissler thermometer reading to $\frac{1}{100}$° C. These results were:—

	Moist Oxygen.		Dry Oxygen.
	I.	II.	III.
Corrected rise of temperature...	3·47° C.	3·4625° C.	3·36° C.
Mean value	3·466° C.		...
Cal. power in Cent. units.........	7203·4		6983·1

These give a difference of 220·8 units in favour of the moist oxygen. In addition to that there is a gain unaccounted for which is due to the latent heat of the water carried off by the gases. This amounts to 181·4 cals. or more than 1·9 per cent. in the above case. The explanation given is that with dry oxygen the combustion is not so perfect as with moisture present, in accordance with all recent investigations of the influence of moisture on chemical change. A list of papers by Dixon and Baker is given at the end of the paper, and the following figures, showing the magnitude of errors from various sources:—

An error of 1 mm. in the reading of the water-level causes an error of about 0·25–0·3 per cent. An error of about $\frac{1}{100}$° C. for 1 grm. of fuel burned, about 0·3 per cent. The effect of neglecting the radiation error varies greatly, but averages from 2–3 per cent. The error due to evaporation at 15° C. is 1 per cent., and that due to the formation of carbon monoxide is from 1–2 per cent.

Discussion.—In the discussion, **W. Thomson** said that he always used oxygen which had stood for twenty-four hours over water in a gas-holder, and he had not been able to find carbon monoxide in the gases in his determinations. **L. Archbutt** described the Mahler Bomb Calorimeter, giving an account of experiments with it on various English coals carried out by the late chemist of the L. & N. W. Railway—a table of these tests with comparative results from L. Thompson's calorimeter being also given. **A. Adams,** in reply, pointed out that although a gas-holder was included in W. Thomson's original apparatus, the influence of moisture was not suspected, and more often the gas-holder was discarded. The Berthelot-Mahler Calorimeter should be compared with results from W. Thomson's as L. Thompson's form was not reliable and results were not uniform. F. J. R.

543. *Powdered Coal.* (Eng. News, 46. pp. 415–416, Nov. 28, 1901.)—In America several systems of apparatus for pulverising coal, and for burning the powdered fuel have been developed, two of the most recent being described in this article, with illustrations of the apparatus. These are the "Cyclone Pulveriser," which is also shown adapted to a 2-Lancashire boiler plant, and the "Aero-Pulveriser," the application of which is shown to seven rotary kilns or furnaces for cement-making at the works of the Michigan Portland Cement Company. Both machines pulverise the coal by impact and attrition at a high velocity against metal surfaces, the lighter of the ground particles being continuously removed by means of a fan which exhausts from the pulveriser and delivers to the burning apparatus. The degree of fineness to which the fuel is ground, and the rate at which the coal dust is fed to the furnaces, are under control by regulating the speed of the fan. [See also Abstract No. 2232 (1901).] F. J. R.

544. *Tests of Mechanical Stokers.* **W. R. Roney.** (Elect. World and Engineer, 38. pp. 1079–1080, Dec. 28, 1901.)—The report of comparative tests of "American" and "Roney" stokers [see Abstract No. 153 (1902)] omitted some considerations essential to a just comparison. The evaporative performance of the boiler is not necessarily a standard of stoker efficiency unless both boilers be of the same type with heating surfaces and settings in the same condition. The author points out that the Babcock-Wilcox boiler and Roney stoker has been in use for over two and a half years, and were not in a good condition when tested, whereas the Stirling boiler and American stoker were quite new. If the results obtained from the Babcock-Wilcox boiler and stoker when new and clean be taken, the cost of coal required per h.p. per hour would be $34·08 instead of $35·76; the cost per h.p. per year would be $36·40 instead of $38·06, and the cost of repairs would also be less, as diminished draught caused the higher repair costs in the table of costs. The function of a stoker is to burn coal—not to] evaporate water—and the measure of its efficiency is the completeness of combustion as shown by analysis of the flue gases. These gases from the Roney stoker showed $CO_2 = 14·2$ per cent., $O = 4·67$ per cent, and $CO = 0·29$ per cent., and as the former evaporation from the boiler to which it was attached was 11·7 lbs., instead of 11·169, in the comparative tests, the Roney stoker was unfairly handicapped in these tests. F. J. R.

545. *Coal Conveyors at Edinburgh Electricity Works.* (Electrician, 48. pp. 291–292, Dec. 13, 1901.)—The coal-conveying plant here described is installed in the McDonald Road Works, Edinburgh, and was erected by the New Conveyor Company, of Smethwick. Small coal is shovelled from railway trucks into a concrete pit, 136 feet long, 14 feet wide, and 10 feet deep. It is then fed automatically into elevators, which have their boots sunk 7 ft. 6 in. below the bottom of the pit. The elevators have 16-inch buckets, attached at 2-feet pitch to the lifting chains, the whole being enclosed in cases inclined at an angle of 60° to the horizontal, the said cases being of ironwork, 66 feet long, and 3 feet by 2 feet in section. Each elevator raises 30 tons an hour, and they deliver together into one hopper. Thence the coal is taken by two 18-inch cross-conveyors across the boiler-house, which contains two rows of boilers, facing each other. It is then delivered through shoots into the middle of either of two longitudinal conveyors, each 12 inches wide by 130 feet long, which run respectively over the fronts of the two rows of boilers, the cross-conveyors being 17 ft. 6 in., and the longitudinal ones 9 ft. 6 in. above the level of the floor of the coal store. The longitudinal conveyors deposit the coal along the overhead stores in sunk steel hoppers, which connect by means of measuring chambers and guide shoots with the stoker hoppers. The coal store is 20 feet above the firing floor level, and contains twenty steel hoppers (one corresponding to each boiler), 11 ft. by 4 ft., by 4 ft. 6 in. deep. The whole is worked by enclosed motors, nine in number, each of 6¾ h.p. The article contains three drawings, which show the plan, cross-section and longitudinal section of the arrangement. The ashes are also automatically removed by other conveyors, which are further fully described. [The Electricity Works are described in Abstract No. 761 (1900).] W. H. S.

546. *Brick Chimneys for Power Stations.* **W. D. Ennis.** (Amer. Electn. 13. pp. 570–572, Dec., 1901.)—The proportions of a chimney are determined with reference to the quality of fuel and amount to be burned per hour, type and dimensions of furnace, boiler and setting, arrangement and size of flues, average and extreme limits of temperature of the external air, elevation above sea-level, variation of atmospheric humidity, and limiting dimensions of the chimney itself. The basis on which evaporation is calculated is that of taking a boiler-h.p. as equivalent to 34½ lbs. water evaporated per hour at 212° Fahr., and atmospheric pressure, and assuming that 6·9 lbs. of water are evaporated per lb. of coal. The consumption of steam in lbs. per i.h.p. per hour may be assumed at: 17½ lbs. for compound condensing engines; 23½ lbs. for simple condensing engines; 30 lbs. for simple non-condensing engines; 40 to 70 lbs. for uneconomical throttling or slide-valve engines, and

100 lbs. for direct-acting simple steam pumps. For a central power station of average size a good brick chimney will cost complete, in the neighbourhood of New York, about $15 per 1,000 bricks. The number of bricks per h.p. varies with the economy of the design. One chimney built for 8,000 boiler-h.p., 10 feet diameter, 225 high, with independent inner core, contained 700,000 bricks above the ground line. Another, 5 ft. 6 in. inside diameter, 125 feet high, contained 230,000 bricks. One built for 3,000 boiler-h.p. contained 450,000 bricks. Another (without inner core) of octagonal shape, with a round shaft, 10 feet in diameter and 125 feet high, had 165,000 bricks. All these are exclusive of concrete foundations. The function of an inner core is to increase the efficiency of the draught by retarding radiation through the chimney walls. This object is secured by the use of hollow bricks which are coming into use. The questions of cost of foundations, thickness of walls, the direction and junction of flues, and the ornamentation of chimneys are also dealt with in this paper. F. J. R.

AUTOMOBILISM.[1]

547. *Locomobile Steam Motor Car.* (Engineer, 92. pp. 622–623, Dec. 20, 1901.)—This car is described, and its working commented on. Great simplicity of mechanism is one of its leading features. Steam is raised in a vertical fire-tube boiler located beneath the seats of the carriage body. The boiler is fired by a gasoline furnace, the spirit being supplied under pressure from a reservoir in connection with which is an air tank in which pressure is raised and maintained by a hand air-pump. Steam is supplied to a simple two-cylinder vertical engine located in front of the boiler. Power is transmitted from the crank-shaft to the live rear axle by means of a simple chain drive. The boiler is about 14 inches diameter × 14 inches high; it has a solid drawn copper shell with steel end plates ¼ inch thick riveted on with ⅜-inch rivets. The shell is overwound with two layers of steel piano wire. The boiler is traversed from end to end by 300 ½-inch copper tubes. The total heating surface is about 42 square feet. One of these boilers tested to destruction bore a pressure of 1,200 lbs. per square inch. The blow-off pressure for normal working is 200 lbs. per square inch. Under the boiler is a flat vessel of sheet steel about 1½ inches deep and traversed by numerous vertical air-tubes about ½ inch bore. In the upper plate of this vessel round the tops of the air-tubes are drilled about 3,000 holes of $\frac{1}{20}$ square inch diameter. The gasoline under a pressure of about 35 lbs. per square inch traverses two of the boiler-tubes, where it is vaporised, and is then injected through a fine nozzle into the furnace pan, and passing out of the holes round the air-tubes the vapour burns with a hot, smokeless flame. An automatic regulator operated by the steam pressure cuts down the petrol vapour supply as the pressure approaches 200 lbs. per square inch. The engine is of very simple construction, the cylinders are 2¼-inch bore × 4 inch stroke, and the speed may be varied from about 11 to 600 r.p.m. At 300 r.p.m., and with an m.e.p. of 100 lbs. per square inch, about 2·4 b.h.p. is developed per cylinder. The chain drive gears down in the ratio of about 2·5 to 1, and the road wheels are 28 inches diameter, so that at 250 r.p.m. of the engine the car travels at about 8 miles per hour. The car weighs about 700 lbs. in running order and carries two persons. C. R. D'E.

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[1] Electric Automobiles are described in the Section dealing with Electric Traction.

548. 100-*Mile Car Test.* **(Horseless Age, 8. pp. 77–82, 1901.)—The following are the results of an independent trial. The highest award was obtained by the "Gasmobile" and "Haynes-Apperson" cars.**

LONG ISLAND AUTOMOBILE HILL-CLIMBING AND ENDURANCE TEST, APRIL 20, 1901.

Make of Vehicle.	Horse-Power of Motor.	No. of Passengers.	Corrected Time. 100 Miles.	No. of Stops.	Total time of Stops. Min. Sec.	Per cent. of Efficiency.	Time. Min. Sec.	
De Dion-Bouton	5	2	6:58	1	9	98·2	1·48	Winner in class below 1,000 lbs.
De Dion-Bouton	5	2	—	—	—	—	3·34	Did not finish course.
De Dion-Bouton	5	2	—	—	—	—	—	Did not reach hill.
Darracq	6	2	7:05:30	5	9:30	98·1	3·30	—
De Dion-Bouton	5	2	—	—	—	—	1·40	Did not finish course.
"Packard"	9	2	7:58:30	4	41:30	91·7	5·50	—
"Gasmobile"	9	2	6:56	None.	None.	100	3·35	—
"Gasmobile"	9	2	—	—	—	—	2·35	Did not finish course.
Daimler (Delivery)	6	4	10:40	4	18	96·4	—	Exact time not taken at top of hill.
De Dion-Bouton	10	2	—	—	—	—	20·25	Did not finish course.
Electric Vehicle Co. ...	5	3	7:26	11	12	97·6	3·05	Winner in class between 1,000 and 2,000 lbs.
"Gasmobile"	9	2	5:34	3	20	96	11·25	Disqualified.
"Gasmobile"	9	2	5:53	1	0:15	99·9	2·39	Disqualified.
Haynes-Apperson	8	4	7:11	None.	None.	100	4·30	—
"Holyoke"	9	2	6:41	1	1	99·8	2·10	Winner in class above 2,000 lbs.

M. O'G.

549. *Alcohol Motor Car Trials in France.* (Engineer, 92. pp. 475–476, Nov. 8, 1901.)—Some particulars are given relating to the trials carried out by the Minister of Agriculture [see Abstract No. 878 (1902)]. The road trials lasted three days, 100 kiloms. being travelled each day, starting from Paris. The following are some of the figures from the second day's run of 100 kiloms. Two Bardon carriages weighing 1,500 kilos and 1,200 kilos, engines 8 h.p. and 5 h.p., consumption 18·194 litres and 12·267 litres of pure alcohol respectively. During 15 kiloms. of level road a 10-h.p. Mors weighing 1,272 kilos consumed 8·78 litres and covered the distance in 18 min. The smaller Bardon took 31 min. for the same distance, and consumed 2·16 litres. A Gillet-Forest of 7 h.p. weighing 800 kilos consumed 8·24 litres of 50 per cent. alcohol for the 100 kiloms. A 7·5-h.p. Delahaye weighing 1,220 kilos consumed 10·27 litres of 50 per cent. A "Société Nancienne" of 10 h.p. weighing 1,240 kilos consumed 11·785 litres of 50 per cent. In the Industrial Vehicle class a Gillet-Forest lorry weighing 940 kilos and carrying 742 kilos covered the 100 kiloms. in 4h. 8m., and consumed 12·922 litres of 50 per cent. alcohol. A Panhard-Levassor lorry weighing 1,020 kilos and carrying 918 kilos took 4h. 30m., and consumed 11 litres of 50 per cent. Particulars relating to the Pengert Postal Van, and the Gobron Brillié, de Dietrich, and Bardon lorries are also given. It appears probable that the 50 per cent. alcohol will alone be able to compete with petrol on the score of cost. Photographs of four of the lorries are given. [See also Abstract No. 158 (1902).] Ç. R. D'E.

550. *Tyres.* **F. W. Barker.** (Horseless Age, 8. p. 100; and pp. 124–125, 1901. Abstract of a paper read before the Automobile Club of America.)—With pneumatic tyres, too narrow a tread cuts into a soft road-bed and too wide a tread wastes power. With the narrow tread flattening always occurs, with loss of stability of tread. No tyre possessing the quality of perfect stability is on the market. Electric welding is found to be the most expeditious and satisfactory method for fastening the tyres to the rim wheels.

M. O'G.

REFERENCES.

551. *Air Navigation.* **J. Armengaud, Jr.** (Comptes Rendus, 133. pp. 996–999, Dec. 9, 1901.)—In this paper a map is given showing the trajectory on the earth of the course of Santos-Dumont's ærostat in the experiment of October 19, 1901.

E. H. C.-H.

552. *Steam Engineering.* **P. Dawson.** (Eng. Mag. 22. pp. 161–176, Nov.; 333–335, Dec., 1901; pp. 519–537, Jan., and pp. 703–720, Feb., 1902.)—This series of articles, with numerous half-tone illustrations, consists mainly of descriptions of the steam plant in a number of British, Continental, and American Electric Power Stations, with a discussion of the principal respective characteristics of their present steam practice. G. W. de T.

553. *Shaft Governors.* **H. F. Schmidt.** (Amer. Electn. 13. pp. 545–548, Nov., 1901.)—This paper contains diagrams and descriptions of some twenty forms of shaft governor used in modern American practice. H. R. C.

554. *Motor Lorries for Military Purposes.* (Engineer, 92. p. 601, Dec. 13, 1901.)—A general account is given of the results of the road trials at Aldershot, together with some particulars of the five competing vehicles. Ç. R. D'E.

GENERAL ELECTRICAL ENGINEERING.

555. *Dielectric Strength of Insulators.* **M. O'Gorman.** (Electrician, 47. pp. 845–846, Sept. 20, 1901.)—The author agrees with Dr. Baur [see Abstract No. 2467 (1901)] that the puncture resistance of an insulator expressed in terms of volts per centimetre at which it breaks down increases when the gap between the electrodes is small, but objects that the evidence is insufficient for Baur's general formula, and points out that the details of his experiment have not been given. Reference is made to Trowbridge's experiment, Maxwell's Electricity and Magnetism, 3rd edition, 1892, art. 51, p. 54, and Kelvin Electrostatics and Magnetism, 84. art. 340, p. 262, second edition. M. O'G.

556. *Losses of Energy in Accumulators.* **B. Hopkinson.** (Electrician, 48. pp. 211–214, Nov. 29; and pp. 263–264, Dec. 6, 1901.)—This paper describes and discusses a number of experiments on the efficiency of accumulators expressed in terms of the ratio of the energy given out to that put back again, not, as is usual, during a complete discharge and recharge, but during short cycles of time ranging from 20 seconds to 30 minutes, the object being to examine efficiency under conditions of working such as are experienced by regulator traction batteries. Two Tudor and one Chloride cell, each capable of giving an output of 7 amperes for nearly one hour were employed. Before each set of experiments the fully charged cells were discharged at a low current for a couple of hours, in order to prevent any evolution of gas during the tests; then, after a rest on open circuit, they were put through a number of similar cycles of discharge and recharge until uniform results were obtained time after time, and from these the curves given in the paper were prepared. A cycle is twice the time of discharge or recharge, which were equal. For one-minute cycles at a current corresponding to about a one-hour discharge rate—conditions approximating to the average treatment of a "floating" battery—the efficiency was slightly over 90 per cent. One-minute cycles at about a six-hour discharge rate—representing a traction battery working on light load—the efficiency reached the very high figures of 96·5 per cent. and 97 per cent. Generally speaking, the shorter the cycle the higher the efficiency. For instance, in one set of experiments the loss of energy in one ten-minute cycle was 35 per cent. to 40 per cent. greater than in ten one-minute cycles, although practically the same energy was put into the cell in each case. The author finds that the more rapid the cycles the more nearly may the whole loss of energy be ascribed to the measured internal resistance of the cell, but that the calculated resistance of the layers of electrolyte between the plates only accounts for a small fraction of the total resistance. For longer cycles losses of energy in another direction besides internal resistance become relatively of more importance. This he has termed "electrolytic dissipation," and believes it to arise from local variations in the strength of the electrolyte and the generation of heat during the subsequent restoration of equilibrium by diffusion. E. J. W.

557. *Accumulator Acid.* **A. Pfaff.** (Centralblatt Accumulatoren, 2. pp. 73–78, and pp. 173–176, 1901.)—The writer has compiled a table showing the different strengths of acid used in the cells of fifteen makers. The

density of the acid varies from 1·142 to 1·120; the latter number corresponds to 29·84 per cent. H_2SO_4. A curve is given showing that the maximum conductivity of sulphuric acid is for 31 per cent. Calculations are made of the necessary variations of the density of the acid during charging and discharging from the assumed chemical reactions in the cell. These values are compared with those actually obtained. The experimental results are exhibited in the forms of curves showing the number of grammes of acid used per ampere-hour at various current densities and similar relations. The author has more particularly studied portable cells, each with two positive and three negative plates, which were charged with sulphuric acid with densities varying from 10 to 30 Béaume. Curves are plotted of the behaviour during charge and discharge of these cells. The following table shows generally the result in four cases:—

Acid density before charging $= a$ ……	24·5	22	17	13
„ „ discharging $= b$…	30	28	22	19
Mean acid density $= \frac{a+b}{2}$ ……………	27·5	25	19·5	16
Charging time in hours ………………	7h. 15′	6h. 20′	4h. 40′	4h. 12′
Discharging „ ………………	6h. 40′	5h. 50′	4h. 20′	3h. 55′
Capacity in ampere-hours ………………	33·3	29·25	21·7	19·8
Mean voltage during charge …………	2·281	2·264	2·217	2·196
„ „ discharge ………	1·976	1·964	1·927	1·908
Efficiency in ampere-hours ……………	91·95%	92·10%	92·86%	93·26%
„ watt-hours ………………	79·66%	79·9%	80·7%	81·02%

W. W. H. G.

558. *Tests of some Primary Batteries.* **F. Peters.** (Centralblatt Accumulatoren, 2. pp. 121–122; 133–135; and pp. 269–270, 1901.)—Tests have been made of two forms of low-resistance primary cells of the Leclanché type called the Reform and the Hydra cells; also of the dry cell of the Columbus Electricitats Gesellschaft, and the results are given here. The last article gives the results of tests on the use of ammonium persulphate as a depolariser. It was found to greatly increase the depolarising power and life of the cell, provided that the current taken was not too large, and that the periods of rest were longer than those of work. J. B. H.

559. *Iron-clad Horn Lightning Arrester.* **E. Klein.** (Elektrotechn. Zeitschr. 22. pp. 1045–1046, Dec. 19, 1901.)—By backing the horns with iron the magnetic field produced assists the hot air in driving the arc upwards. Under conditions in which, without iron backing, the arc remained across the narrow gap, with backing it was immediately driven upwards and extinguished. It was effective also in driving the arc downwards, when the arrester was inverted, against the action of the hot air. The negative end of the arc rises more quickly than the positive. G. H. B.

560. *Electrical Operation of Machinery.* **R. T. Lozier.** (Elect. Rev. N.Y. 39. pp. 754–758, Dec. 21, 1901. Paper read before the New York Electrical Society, Nov. 26, 1901.)—A review is given of previous papers on the subject, with examples of the most recent practice. In large establishments it is found that, with individual motor driving, the average load on the generating plant is but 1/6, or 16⅔ per cent. of the total connected load.

The ratio of cost of power to the product of the shop is given. With the

cost of steam power at £7 10*s*. per h.p. per year, the average ratios are said to be 2 per cent. of product for complete belting transmission, 1 per cent. for subdivided motor transmission, and 0·4 per cent. for individual motor transmission. With triple expansion engines the cost per h.p. year is put at £5, and the corresponding percentages are $1\frac{2}{3}$ per cent., 0·8 per cent., 0·4 per cent. Under the very best conditions, therefore, the subdivided motor system would effect a saving in a works producing annually to the value of £207,000, sufficient to pay 10 per cent. per annum on a plant costing £17,500, and the individual motor method would support at the same rate a plant costing £27,000. Owing to the increased speed control with the individual motor system, the output of a works can be increased from 8 per cent. to 25 per cent. with the same equipment and pay roll. An instance is given of a printing works in which the output was increased 80 per cent. Assuming only a 10 per cent. increase, this means, on the same basis as before, an increase of £20,700. Allowing £5,175 for raw material, the motor equipment is credited with £15,525, which will probably more than pay for the entire equipment of individual motors in the first year, besides the saving in power transmission. Several illustrations of motor-driven machines are given. [See also Abstract No. 321 (1900).]
F. B.

561. 135-*Ton Electric Crane.* (Engineer, 92. p. 454, Nov. 1, and pp. 561–562, Nov. 29, 1901.)—This crane, which is worked by four motors, was constructed by Vaughan, of Manchester, for Armstrong, Whitworth & Co. Three of the motors are secured to the outer side of the crab, and run at 800 r.p.m. Each is controlled by a resistance of the liquid type, placed in the operator's cage. The girders are of double-web section, being 54 feet in length, 4 feet deep at their terminations, and 6 feet deep at their centres. The top and bottom booms consist of two steel plates, each 1 ft. 7 in. wide by $\frac{7}{8}$ inch thick, the web plates being $\frac{5}{16}$ inch thick. The fourth motor is carried at one end of the crane, for operating the longitudinal travel, which is at the rate of 200 feet per minute. The travelling speed of the crab is 100 feet per minute. For the main hoist two barrels are provided, rotating in opposite directions; the reduction of speed is effected first by worm and worm-wheel, and then by spur-wheels and pinion. The usual electromagnetic brake, which raises and lowers the brake levers, is provided. Two rates of hoisting are allowed for, the change wheels and clutch gear being operated from the platforms. There is also an auxiliary barrel for dealing rapidly with loads up to 10 tons. Three drawings are given, showing the general construction.
W. H. S.

REFERENCES.

562. *Motor-starting and Reversing Switch.* **R. Krause.** (Elektrotechn. Zeitschr. 22. pp. 1066–1067, Dec. 26, 1901.)—An illustrated description of an automatic motor-starting and reversing switch, fitted with no-voltage and overload electromagnets.
A. H.

563. *Electrical Appliances in Ship-building Yards.* **S. F. Walker.** (Eng. Mag. 22. pp. 679–692, Feb., and pp. 854–870, March, 1902.)—The various appliances illustrated and described include electrically driven bending rolls, a cold saw, cranes and winches, pumps, and general machine tools both fixed and portable.
G. W. de T.

GENERATORS, MOTORS, AND TRANSFORMERS.

564. *Standardising Electrical Machinery.* **J. T. Broderick.** (Eng. Mag. 22. pp. 24–30, Oct.; and pp. 177–184, Nov., 1901.)—The author considers generally the effect of standardising electrical machinery on the questions of cost, delivery, and quality. The voltages and frequencies standardised by the American Institution of Electrical Engineers are given by the author as follows: For continuous-current low-pressure generators, terminal voltages 125, 250, and 550; for continuous-current and alternating low-pressure circuits, terminal voltages 110 and 220; for continuous-current power circuits for railway and other service, voltage 500; for alternating-current high-pressure circuits, voltages at the receiving end, 1,000, 2,000, 3,000, 6,000, 10,000 15,000, and 20,000; for alternating current high-pressure generators, or generating systems, terminal voltages, 1,150, 2,300, and 3,450. A maximum drop in transmission of 15 per cent. of the pressures at the receiving end is allowed in the voltages specified for high-pressure alternating currents. For alternating-current circuits, frequencies 25, 30, 40, 60, and 120. G. W. de T.

565. *Effect of Dimensions of Teeth on Output of Dynamos.* **M. Corsepius.** (Elektrotechn. Zeitschr. 22. pp. 988–991, Nov. 28; 1003–1006, Dec. 5; and pp. 1023–1026, Dec. 12, 1901.)—In this paper the author considers in detail the effect of varying the size and shape of the teeth on the output of the armature, taking into consideration the permissible limits as regards sparking and heating. The teeth being strongly magnetised, the author assumes that the law B = constant + H may be used in investigating the distribution of induction along a tooth. The diameter *d* (in cms.) of the armature is given by the formula—

$$d^3 = \frac{10^8 . \mathrm{E}.g.p.0{\cdot}675}{\zeta\,(1-\zeta).\mathrm{C.D.B.}n.m},$$

where E = e.m.f., in volts; g = diameter of covered wire used in winding armature in millimetres; p = number of poles; ζ = ratio of width of tooth to pitch of teeth; C = ratio of length to diameter of armature; D = ratio of pole-arc to pole-pitch; B = apparent induction in teeth; n = revs. per min.; m = number of wires per slot. The greater part of the paper deals with the effect of altering ζ on the performance of the machine as regards sparking and heating. In connection with the former, the author states that the armature cross-turns should not exceed from ¼ to ⅓ of the ampere-turns required for maintaining the flux across the (double) air-gap and in the teeth. A. H.

566. *Voltage-Drop in Alternators.* **J. Fischer-Hinnen.** (Elektrotechn. Zeitschr. 22. pp. 1061–1065, Dec. 26, 1901.)—The two methods commonly in use for predetermining the regulation of an alternator from its open-circuit and short-circuit characteristics are those due to Behn-Eschenburg and Rothert. In Behn-Eschenburg's method, the equivalent inductance of the alternator armature is found from the short-circuit curve, and the drop due to it is compounded vectorially with the p.d. to give the e.m.f. In Rothert's method [see Abstract No. 591 (1900)] we have the composition of ampere-turns instead of e.m.f.'s. The author gives a table containing the experimentally determined values of the p.d. and the calculated ones for fifteen different machines, and from this table it appears that in general the values calculated by Behn-Eschenburg's method are too low, while those obtained by Rothert's method are too high. A much better agreement is obtained by using a recent method due to Potier, which may be regarded as a combination of the above two methods. Potier compounds the field and armature ampere-turns, thus finding the resultant ampere-turns. But instead of taking—as is done in Rothert's method—the value of the e.m.f. corresponding to the resultant ampere-turns (and obtained from the open-circuit curve) to represent the p.d., he further subtracts from this e.m.f. (vectorially) the inductance drop in the armature, thus getting the p.d. The method is somewhat tedious, and tables are given by the author to facilitate the necessary calculations. A. H.

567. *Compounding of Alternators.* **A. Heyland.** (Elektrotechn. Zeitschr. 22. pp. 1021–1023, Dec. 12, 1901.)—As applied to an alternator of ordinary construction, this method consists in providing the rotating field magnet with an additional winding resembling Leblanc's *amortisseur*, but connected to a commutator, by means of which it may be supplied with the main alternating current. The arrangement is diagrammatically shown in Fig. 1, in which the shuttle-shaped portion represents a 2-pole field magnet. By suitably adjusting the position of the brushes, the magnetic effects due to leakage and armature reaction may be balanced by the magnetic effect due to the compound winding, which may also provide a sufficiently large field to compensate for the resistance drop. Instead of full, partial compounding may be used. The compounding of alternators may be adopted with advantage in the case of single machines; where machines are run in parallel compounding is excluded, since its adoption would annul those controlling currents on which satisfactory parallel running depends. But one or two machines might be compounded, and would then supply the wattless component of the current. [In the case of two machines, the current of the first machine would supply the compound winding of the second, and *vice versâ*—an arrangement similar to that used in continuous-current generators.] The author next considers the application of his method of compounding to an asynchronous generator of the type recently described by him [see Abstract No. 2475 (1901)]. In this case, all that is necessary is to provide another set of brushes, through which the main current may be introduced into the rotor winding. The arrangement in its simplest form is shown in Fig. 2, in which *bb* are the brushes supplying the exciting current, and BB those supplying the compounding current. A. H.

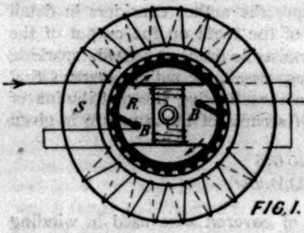

FIG. 1.

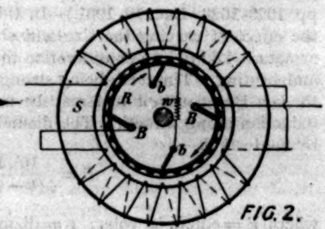

FIG. 2.

568. *Measurement of Coefficients of Speed Variation of Alternators.* **J. Blondin.** (Écl. Électr. 29. pp. 252–258, Nov. 16, 1901.)—Owing to the variation of engine effort during the stroke and the obliquity of the connecting rod, the flywheel of an engine varies in speed in one revolution between Ω maximum and Ω minimum ; the *coefficient of variation* during one revolution is defined as—

$$k = \frac{\Omega \text{ max.} - \Omega \text{ min.}}{2\,\Omega \text{ mean}}$$

There is also another variation of longer period due to the elasticity of materials and to want of balance in any rotating parts whose angular speed is a submultiple of that of the main shaft. Admitting the periodicity of this latter variation, a new coefficient, that of variation during n revolutions, is required ; and this is defined similarly as—

$$k' = \frac{\Omega' \text{ max.} - \Omega' \text{ min.}}{2\Omega' \text{ mean.}}$$

Ω' being, with the respective suffixes, the maximum, minimum, and mean angular speeds during n revolutions.

If an ideal crank moving uniformly makes one whole turn in the same time that a real crank makes a whole turn with a varying speed, the two cranks will form at every instant an angle varying between zero and a maximum value θ. This angle θ is defined as the *angle of maximum displacement* during one revolution. θ' is the maximum displacement during n turns. The angle of maximum displacement is, generally speaking, a complicated function of the coefficient of variation, and it is not possible to evaluate the one quantity from a knowledge of the other. If, however, the actual speed is known at any instant, an integration will give the maximum displacement. The determination of this latter quantity, therefore, reduces to a measure of the instantaneous speed of rotation.

Such measurements may be classified as (1) mechanical, (2) acoustic, (3) electrical, and (4) optical. *Mechanical methods* compare the actual instantaneous speed of a revolving part with that of another body moving either (*a*) periodically or (*b*) with a uniform movement of rotation. Two arrangements are described under heading (*a*) in which a tuning-fork to which a uniform longitudinal motion is given traces a sinuous curve on a piece of smoked paper wrapped on a revolving cylinder rigidly coupled to the shaft of which the variations of speed are to be measured. The varying distance between the peaks of the waves is a measure at any instant of the actual velocity of the cylinder. This method demands great nicety of measurement of the order of 1/100th of a mm. The other mechanical method compares the variable motion with that of a disc or flywheel with a very large moment of inertia, connected with the shaft of variable motion by friction gear or an elastic coupling. This method is not nearly so exact as the former, and besides this the speed of the disc is that of the mean velocity of the shaft during a number of turns, and does not give the quantities k and θ corresponding to one revolution. (2) *Acoustic methods.*—The principle of these is to produce a note of which the pitch corresponds to the instantaneous speed of the shaft, *e.g.*, by means of a toothed wheel and card. This method lacks sensitiveness. (3) *Electrical methods.*—One way is to measure the instantaneous e.m.f. of a small direct-current dynamo mounted on the shaft of the machine. The current from the dynamo passes through a differential galvanometer, of which one winding is fed by a steady current from an independent source. The latter is adjusted so that at the mean speed the galvanometer gives no deflection; a movement of the needle in one direction or the other indicates a corresponding increase or decrease of speed in the shaft. The objections to this method are (1) that the speed variations detected are not those occurring in one revolution, but relate to the mean speed of several revolutions; (2) errors are introduced by commutation and want of symmetry in the windings; (3) self-induction produces exactly the same effect as the elastic coupling in the mechanical methods, and involves the same lack of sensitiveness. In this connection an ingenious method, due to Claude, is described for magnifying the angular displacements to be observed. A bicycle wheel is applied against the rim of the flywheel; by reason of the perfect adherence of the rubber tyre, and the small inertia of the wheel, the fluctuations in movement of the flywheel are faithfully reproduced, and the angular displacement magnified in proportion to the diameters of the two wheels. On the axis of the bicycle wheel are fixed the field magnets of a small motor, with brushes attached. A current is passed through the armature such as to turn the latter in the opposite direction to that in which the bicycle wheel rotates, and at an equal speed. The armature is then motionless in space. An index attached to the shaft will then show by its movement in one direction or the other any increase or decrease in the speed of the bicycle wheel, and therefore of the flywheel from which its motion is derived. (4) *Optical methods.*—These do not involve any of the difficulties which are met with in the other methods. In the case of an alternator with rotating fields a fixed beam of light passing between the moving pole-pieces is examined through a slot in a revolving disc. If the movement of the alternator is perfectly regular and the speed of the disc is adjusted so that the slot is always in the same position when the beam of light is passing through the spaces between the field-poles, these will appear motionless; if the speed of the alternator varies between a maximum and minimum, the image on the retina will oscillate between two extreme positions, the angular displacement of which will be double the angle θ required. One or two modifications of this stroboscopic method, which is capable of great accuracy, are described. B. P. S.

569. *Street Railway Motors.* **G. T. Hanchett.** (Street Rly. Journ. 18. pp. 521–525, Dec., 1901.)—This paper deals with the principles upon which the selection of railway motors for given work should be based. Makers' ratings are an insufficient guide; reference must be made to actual performance curves over the limits of load. These are placed as follows, in order of importance; in all cases the load in amperes is plotted as abscissæ: (1) Horizontal effort, or draw-bar pull; (2) speed; (3) temperature; (4) horse-power input; (5) efficiency; (6) horse-power output. The author discusses each of these curves, of which typical examples are reproduced, briefly explaining the causes which determine the particular character of each, and showing how one curve can be checked against another, and inferences can thus be drawn as to whether manufacturers' curves show the results of actual tests or not. In the temperature curve, otherwise called the time curve, minutes are plotted against amperes, the ordinates showing the time taken under any given load for the motor to reach a limit of temperature, say 75° C. above that of the air. The latter part of the paper is given up to a discussion of the heating problem; and a method is indicated of determining the heat performance of motors with due regard to the complex conditions of actual working. The principle is to ascertain experimentally the thermal capacity C of the motor—that is, the number of units of heat, expressed in kilowatt-hours, which raise it to a given temperature T, taken as the permissible heating limit; and R the rate of radiation at the same temperature, in watts, is also found experimetally. For a level run, by integration of a loss curve, plotted with reference to the current load, with time for abscissæ, the total heat delivered to the motor within the period 0 to L is found; thus $\frac{E}{L}$, the average rate of radiation during the run, can be found, which must of course not exceed R on an extended run. The problem is more extended on gradients, or where the load is for a considerable period much over the normal. Here the heat inertia or reserve capacity of the motor—*i.e.*, the difference between C and the heat contained in the motor at the beginning of the run—is depended upon to store up the heat generated, to be radiated at a more favourable time. The formula $\frac{2C(LR-E)}{R(2iL-LR-E)}$ is deduced as an expression for the permissible time that the motor will carry the load under the given conditions ($i =$ the loss in watts). Suggestions are made as to the methods by which the thermal capacity C and rate of radiation R should be determined; and it is pointed out that C is not really a constant but a function of the current; for important calculations various values of C at different currents should be experimentally determined and embodied in a curve, and that value of C should be selected which corresponds to the r.m.s. of the currents about to be applied to the motor.

B. P. S.

570. *Testing Induction Motors.* **A. S. M'Allister.** (Elect. World and Engineer, 39. pp. 78–80, Jan. 11, 1902.)—Simple methods are shown for determining the slip, stator and rotor losses, &c., of polyphase induction motors. The percentage of slip is equal to the ratio of copper losses in the rotor to the total power impressed on it. By measuring the current in the rotor and its resistance the slip may be determined. In the case of a squirrel-cage rotor the resistance is measured indirectly by clamping the rotor, supplying current as to a short-circuited transformer, measuring the total power supplied and deducting the C^2R losses in the stator. *Torque.*—This is shown to be equal to the rotor input divided by the speed of synchronism. Measuring the power supplied to the motor, deducting the stator losses, and dividing by the synchronous speed, gives the total torque. On further deducting frictional losses the effective torque is obtained. *Power-factor.*—In a two-phase motor the wattmeter measurements on the two phases are $CE\cos\phi$ and $CE\sin\phi$ respectively. The ratio of these readings gives $\tan\phi$. In a three-phase motor readings on two phases give $W_1 = CE\cos(\phi - 30)$ and $W_2 = CE\cos(\phi + 30)$ respectively, whence $\tan\phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$. Curves and tables are given showing the results obtained by these methods. [See also Abstract No. 83 (1902).]

A. E. L.

571. *Induction Motor used as Synchronous Motor.* **E. Danielson.** (Elektrotechn. Zeitschr. 22. pp. 1065–1066, Dec. 26, 1901.)—An over-excited synchronous motor may, as is well known, be used for improving the power-factor of an inductive load. The reason why such motors have not been more largely used is due to the difficulty of starting them, and to the fact that it is impossible to start under load. This difficulty may be overcome by using an ordinary induction motor with a star-connected three-phase rotor winding, and converting it into a synchronous motor by sending a steady current through one of the phases, the current returning through the remaining two

phases connected in parallel. The author describes the characteristics of such a motor, mentioning the results of some experimental tests. So long as the overload does not exceed 50 per cent., the motor will continue to run in synchronism. Beyond this point it gets out of step, but instead of stopping—as would be the case with an ordinary synchronous motor—it goes on running as an induction motor; there being appreciable fluctuations in the speed and the (continuous) rotor current. In order once more to bring the motor up to synchronism the load has to be reduced to half its normal value. In starting such a motor it would be used as a simple induction motor, and when it has attained full speed the rotor would be polarised and pulled into synchronism. The author draws attention to the fact that since two of the phases of the rotor winding are short-circuited, they will act as damping coils and prevent hunting. A. H.

572. *Polyphase Motor with Three Speeds.* (Zeitschr. Elektrotechn., Wien, 19. pp. 637–641, Dec. 29, 1901.)—Motors built by C. Wüst & Co. of Seebach, near Zürich, have three stators arranged coaxially with a common squirrel-cage rotor. The three stators are wound with different numbers of poles so that different speeds may be obtained by supplying current to one or another. If two stators be supplied with current in parallel, the motor runs at approximately the speed corresponding to that with the greater number of poles. The output can thus be doubled, but at a great sacrifice of efficiency; the losses due to the great slip of the rotor with reference to the second stator are so great that this load can only be kept on for a few minutes at a time. The arrangement may be employed for temporary overloads. All three stators may be switched in together to give triple output, but with even greater sacrifice of efficiency. Some curves are given, obtained from a 8·5-h.p. motor with 4-, 6-, and 8-pole stators, arranged to give this output continuously on a 50-cycle circuit, or two or three times this power for short periods. Its weight is 290 kg. A. E. L.

573. *A Simple Alternating-Current Motor.* **P. Boucherot.** (Ind. Élect. 10. pp. 541–542, Dec. 10, 1901.)—Hospitalier, in the simplest form of his "ondograph," uses a small synchronous alternating-current motor which requires no excitation with direct current. The rotor is simply a bundle of iron stampings, the length of which is about four times the breadth, and the stator is an alternating-current magnet. The author makes calculations to find the amount of power that can be obtained from such a motor. He regards the motor as a coil of variable self-inductance $L(a - \cos 2\omega t)$, where a is a constant greater than unity. He then finds expressions for the power absorbed by it when fed at constant pressure and at constant current respectively. The theory is instructive, but of course the power-factor and the efficiency of this kind of motor are small, and, as the rotor has to be brought into synchronism by external means, it is only useful when very little power is required. A. R.

REFERENCE.

574. *Polyphase Machinery.* **A. C. Eborall.** (Soc. Arts, Journ. 49. pp. 749–757, Sept. 13; 761–768, Sept. 20; 773–782, Sept. 27; 785–792, Oct. 4; 797–808, Oct. 11; 809–818, Oct. 18; 821–831, Oct. 25, and pp. 833–844, Nov. 1, 1901.)—A series of lectures dealing with the question of the design of polyphase generators, transformers, and motors, containing much useful theoretical and practical information. W. H. S.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

575. *Locating Faults in Underground Cables.* **H. G. Stott.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 807–811, Nov., 1901.)—It is pointed out that with small conductors, such as those used for telegraph cables, the ordinary Blavier and loop tests suffice, but, since the percentage error in locating a fault varies directly with the cross-section of the cable, these methods cannot be depended on, and hence are of no practical value for lighting and power purposes. There remain three other methods, which may be called—(*a*) The cut-and-try method. (*b*) The smoke method. (*c*) The compass method. The first of these simply means cutting the cable into as many sections as necessary until the fault is finally located in a length between the manholes. This is a slow, expensive, and unscientific method, and should only be used as a last resort. The smoke method is also crude, consisting, as it does, of passing a current of sufficient strength through the cable into the fault so as to cause the insulation to burn and to give out volumes of smoke, by means of which the location of the burnt part may be discovered on opening up the manholes. The writer believes that the compass method is the only practical and safe procedure. A current of about ten amperes is sent through the cable into the earth; this current is reversed automatically every ten seconds. A manhole is then opened near the centre of the cable length, and a pocket compass laid on the faulty cable and observed for say half a minute. If the fault is further away from the source of the reversed current, the compass will have its direction periodically reversed. The test is repeated at a more distant manhole, say a mile further from the source of the reversed current, and so on until the fault is located between two manholes. The form of reverser used by the Manhattan Railway Company consists of a ½-h.p. three-phase induction motor, geared to a two-part commutator, which revolves in oil in order to insure the quick reversal of current without danger of arcing across the segments. As a source of direct current, a continuous current arc-light machine, or a 500-volt supply with a resistance in circuit, may be used. Before putting on the reversed current it is advisable to break down the fault by the application of a high-pressure testing transformer for a few seconds. The method of testing is particularly useful in a network of cables because the test can be applied without shutting down, providing it is an alternating system and there is no permanent earth. The author has used the method for four years with most satisfactory results. W. W. H. G.

576. *Cables in a Solid System.* (Elect. Engin. 28. pp. 554–555, Oct. 18, 1901.) —Siemens and Company's solid system consists of troughs of hard salt-glazed stoneware in lengths of about two feet. The ends of the lengths form a spigot and socket joint, but the spigot piece forms a bridge which supports the cable in lieu of separate bridges of wood used in other systems. The troughs are covered with stoneware slabs. No cement or jointing material is used. The trough is presumably filled in with bitumen. Joints in the lead-covered cables are made, without soldering the lead, by making up the insulation with a non-hygroscopic tape which extends over both ends of the lead casing. A lead tube, previously slipped over the cable, is drawn over the joint and merely bound down with wires on to the non-hygroscopic tape, which acts as an elastic packing. M. O'G.

577. *Long-Distance Transmission Lines.* **C. W. Startsman.** (Elect. Rev., N.Y. 39. pp. 781–786, Dec. 28, 1901.)—The paper deals with the general theory of the transmission of current-waves along a line of considerable length, the resistance, inductance, and capacity of the line being all taken into consideration. The problem is treated graphically and analytically, and is illustrated by a numerical example. A. H.

578. *Wiring Rules in Germany.* **F. Ross.** (Zeitschr. Elektrotechn., Wien, 19. pp. 593–595, Dec. 8, 1901.)—The author deals with some of the alterations which have been introduced by the new wiring rules lately sanctioned by the Verband Deutscher Elektrotechniker, and also points out certain differences which exist between the Austrian and German regulations. W. H. S.

579. *Electrical Distribution in Large Cities.* **L. A. Ferguson.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 791–805, Nov., 1901.)—This paper deals mainly with the electrical supply stations of Chicago, where the old method of a number of steam-generating stations scattered throughout the city is now generally given up, the smaller generating stations being converted into sub-stations, and the generation being centralised in one or two large power stations suitably located as regards water and coal supply. Several power stations exist in Europe and America arranged for an ultimate output of 50,000 to 100,000 h.p. In some cases the old power stations which these large stations supplant are retained as sub-generating stations and used during the heavy load in the winter months. Even with the relatively high cost of generation at such stations a saving is found to be effected on the alternative method of providing extra plant at the main station sufficient to cope with this load. Choice of site for main power-house is important; the author discusses the points to be considered in deciding the question. As regards the system to be adopted, he advocates direct current for the lighting and power work of the strictly business and city residential districts, and alternating for the more scattered residential and suburban portions. Analysis of the output of Chicago Central Station Companies (railways excluded) shows that 23·4 per cent. is by 60 periods distribution over an area of 58 square miles, and the remainder by direct-current distribution over 10 square miles. As regards the particular company in which the author is interested, as the present plant becomes obsolete it is being replaced by 25-cycle generators, with rotaries in substations to supply the districts of large demand, and motor generators delivering 60-cycle current in districts where electric development is less advanced. The distribution of continuous current by rotaries is in this station rapidly gaining ground on that produced by continuous-current generators, the latter being expected to show only a slight increase over last year's output, while the former is expected to increase by 300 per cent.; but it will take several years to make the complete change from generation by direct current to that by 25-cycle alternating current without sacrificing the value of present investment in plant of the former type.

As regards the supply of current for power, the output of two Chicago companies is nearly 31 per cent. for power (about two-fifths of this being for elevator work) as against 69 per cent. for lighting, taken over the whole year. The importance of the power business has led to the adoption of the three-wire direct-current system in the business and city residential districts. As against alternating motors, the original cost of direct-current motors and their equipment is much less; the author considers the present selling price of three-phase motors in America to be excessive. For lift work also, alternating motors are not nearly so well adapted as direct-current motors. The ability to instal an economical and reliable lift equipment is often a determining factor in the choice between central station service and the installation of a private plant, and by its aid a decided saving over hydraulically worked lifts has often been shown by owners of large mercantile establishments, &c., who have adopted the former method. The growing necessity for charging equipments for automobiles is also adduced as an argument for direct-current distribution, and the advantages of storage batteries are dwelt upon from the points of view of pressure regulation, for discharging during the peak of the load, or for emergency or breakdown. A particular application is indicated of the storage battery, when it is located at the central distributing point of a system with feeders radiating to various points in the network, more or less distant from the centre; by the use of two or more end cell-switches which can be connected to one or more auxiliary bus-bars with a different number of cells in series, different potentials may be provided at the centre of distribution, and the pressures at the far ends of the various feeders can thus be equalised during times of heavy load. At the author's station the system of generation adopted was 25-cycle three-phase current, generated by double-current machines arranged for stepping up to 4,500 and 9,000 volts. The necessary three-phase current for the outlying rotary substations can thus be supplied very efficiently, the generators supplying at the same time direct current to the low-tension network. One of these double-current machines has a capacity of 2,500 kw., generating 300 volts direct current and 180 volts three-phase alternating. Additional plants will be 25-cycle three-phasers, generating directly 9,000 volts, the line pressure. The periodicity chosen was selected in preference to 60 cycles as being less expensive in first cost of plant, giving smaller loss in high voltage underground transmission, with less strain on the insulation in case of any disturbance of the system, and as being more suitable for operating rotaries. The paper concludes with a description of the general arrangement of the service in three districts of Chicago where 60-cycle transmission (formerly 125-cycle) is in use, accompanied by a map showing the positions of the main generating stations and substations, with the principal mains and feeders; and with a brief comparison of the systems employed in Berlin and Milan with that described by the author. B. P. S.

580. *Electrical Distribution in Cities of Moderate Size.* **W. L. Robb.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 843–848, Nov., 1901.)—The author explains that by "cities of moderate size" he means those having a population of 200,000 or less. Towns of less than 50,000 inhabitants form a class by themselves. In this smaller class, in which there is generally a considerable area to be lighted extending in all directions perhaps two or three miles from the central station, and in which there is usually no tendency to put in isolated plants, and little objection to overhead wires, the author would generate only three-phase alternating current at 60 periods and about 2,300 volts. The street arc lighting should be by constant-current series enclosed lamps, the distribution for lighting being generally single-phase; motors under 3-h.p. would also be best operated from the single-phase system. At points where there is any concentration of lighting and power a 220-volt

3-wire system of secondary wiring should be used, being supplied by one or more transformers placed at suitable points. In cities of the larger class (between 50,000 and 200,000 inhabitants), the area lighted is very large, and while commercial lighting and power is concentrated in sections, lighting and power service has to be supplied practically everywhere. In this class of cities there is a tendency to instal private plants, and underground distribution is imperative.

The conditions existing at present in the business section of such cities make it desirable that the supply here should be a direct current one, and the author prefers a 220-volt to a 440-volt 3-wire system, considering that the saving in copper, if the higher pressure is used, is more than counterbalanced by the inferiority of high-voltage lamps, either arc or incandescent. The direct current would be supplied from rotaries in substations, the primary generation being 3-phase, 60 period, 4-wire at a pressure of 2,300 volts. The pressure on the D.C. side would be varied by means of the static transformers used in connection with the rotaries, no boosters being required. The distribution boxes should preferably be of the lamp-post type, so as not to obstruct traffic. The distribution outside the business section should everywhere be on the alternating system. From the power-house the current should be taken, 3-phase 4-wire, to various distributing centres, whence the supply should be ordinarily by single-phase circuits, except where large motors are used, when additional phase-wires would be taken from the distributing centres. In congested areas the distribution should be by 220-volt 3-wire secondary mains fed by large transformers; the neutral wire should be earthed. Street lighting should be by series constant-current arcs. To ensure a satisfactory alternating-current distribution of any size, it should be possible to supply current to the different feeders at different pressures, which can be done by boosting transformers or by Emmet's automatic device. B. P. S.

581. *Three-phase Distribution with Single-phase Circuits.* **W. L. R. Emmet.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 833–841, Nov., 1901.)—The author of this paper prefers a three-phase system to a single- or two-phase, for the reason, amongst others, that while for single-phase working it is better than two-phase, a three-phase generator is as good and cheap when used as a single-phase machine as if it had been designed specially for this purpose. It thus meets either of the other systems on equal terms in their own field, while keeping its own special advantages. For use on single-phase circuits a three-phase generator should have a Y-connected winding. Motors and rotaries tend to equalise the load between the phases, and thus increase the capacity of the system. The only part of a lighting company's load which cannot be advantageously divided between the phases is the low-pressure interconnected distributing system; but there will generally be outlying circuits, which can be worked from other phases. Arc-lighting transformers, &c., can also be put upon the least-used phases, and help to balance the system. Practically the three-phase generator can be used at its rated capacity on any system. The variations of pressure between the phases, due to want of balance when single-phase circuits are being operated, are generally small, and can easily be controlled by regulators in feeder circuits. They may in some cases be actually a convenience, since they give a choice of pressure to suit any feeder. Two systems of low-tension distribution in connection with three-phase generators are discussed, viz., the single-phase, three-wire, and the three-phase, four-wire systems, diagrams being given of each. The former is favourably contrasted with direct-current

three-wire systems, and shown to give, with intelligent handling, practically perfect regulation. The three-phase, four-wire method is probably the most desirable when it can be consistently used on a large scale, but should only be employed where a good balance of the phases can be ensured. The copper economy is slightly in favour of this system as against the other, and it has the advantage that its outside wires are available for operating motors. When the single-phase, three-wire system is used, a fourth wire must be specially run for this purpose. After stating some simple rules to be kept in view when arranging distributing systems, the author describes the method of primary distribution which consists in connecting the Y-winding of the generator to four feeders—three outsides and a neutral. The pressure between each outside wire and the neutral being 2,300 volts, and between the outside wires 4,000 volts, the generator is loaded as if it consisted of three separate single-phase machines; 2,300-volt transformers being placed across the neutral and any of the outside conductors, the result is virtually a three-phase transmission at 4,000 volts. Lines in the immediate vicinity of the power-station can be worked from single-phase branches; the neutral should be used simply as a common return where convenient. For cases where the principal loads are found close to the station, but where there are certain long branch lines which it is desirable to operate at high voltage, the author advises low-pressure three-phase generation, the distribution near the station being direct from the generator, and for the long lines through step-up transformers. The alternator is wound for, say, 125 or 250 volts between the outside and neutral wires; standard 220 or 440-volt motors can then be connected to the outside wires. B. P. S.

582. *Working Costs of Isolated Plants.* **I. D. Parsons.** (Eng. Mag. 3. pp. 573–588, Jan., and pp. 721–736, Feb., 1902.)—The author has collected a considerable amount of information in New York, bearing on the expenses of working private plants, several of which were, however, on an extensive scale. The figures for seventeen such installations are given in full, together in some cases with load curves, &c. Each of the seventeen cases is considered separately, and the circumstances in connection with each are noted. The buildings vary from a large block of offices, 20 floors high, standing on ground 70 feet by 100 feet, having 10 lifts, and 575 kw. of plant installed, down to a club, 5 floors high, standing on ground 35 feet by 100 feet, with no lifts, and 20 kw. installed. The cost per unit in the latter case, in which the dynamo was only run from 4 p.m. to 1 a.m., and no battery was used, was about 5d., and in the former case about 2·2d. The original paper should be consulted for particulars as to the results of working in the various buildings considered. The author thinks that on the whole the statistics show the decided advantage of the isolated plant over the central station service. This is said to be more noticeable in the case of the smaller installations, seeing that they would be charged by the central stations at a higher rate, and some further saving is also experienced through heating the buildings by exhaust steam. The question of heating is, from the American point of view, of great importance; and the author thinks that this consideration alone to a great extent justifies the existence of isolated plants in most cases. W. H. S.

583. *Alternating Current Distribution.* **C. F. Guilbert.** (Écl. Électr. 29. pp. 381–391, Dec. 14, 1901.)—This paper consists of descriptions of various recent inventions in connection with the distribution of energy by alternating

currents. Descriptions are given of—(1) An extension of C. F. Scott's well-known method of transforming from two- to three-phase current. In the method now described the transformer is dispensed with, a compensator or auto-transformer being used in its place. (2) A device due to Lamme for varying the pressure in a distributing network where the pressures or the currents are too great to allow of the ordinary methods being used. This is effected by means of a booster in the circuit, the primary of which is supplied from an auxiliary winding on the transformer, of which any desired number of turns may, by means of a multiple contact switch, be brought into use. (3) The method devised by Steinmetz of transforming the frequency of an alternating current by means of induction motors run "in cascade." The rationale of the method depends on the fact that if we have two synchronous motors, of which the rotors are rigidly coupled, the stator of the second machine being supplied from the rotor of the first, and the rotor of the second short-circuited or coupled up to a rheostat, the coupled rotors of such a system will revolve at a speed corresponding to about half the frequency of supply. Two or three modifications of this principle are described. (4) A device of Steinmetz for diminishing the "all day" iron losses in transformers. Two transformers are used, the smaller one of capacity large enough to take the ordinary day-load, and the other for the full night-load. The two have a common pole, both on the primary and secondary windings; from the other poles of the primaries two separate leads run back to the generator, one or both being connected thereto, as may be required. (5) An arrangement devised by Potter for starting up rotaries without the use of secondary batteries. A motor-generator system is used, the motor being fed from the alternating mains. An improvement is to use a generator with two armatures and separate field magnets. One of the machines is employed to excite the field of the rotary which is to be started, and the other for the armature only. (6) Elihu Thomson's constant-current transformer. [See Abstract No. 406 (1902).] (7) To prevent the hunting of rotaries when run in parallel, which he puts down to ohmic drop in the line, W. J. Davis would only run each machine in parallel at light loads, and would provide that as far as possible each machine should at full load be run by its own generator. (8) A method described by A. D. Lunt of electrically coupling two or more alternators of the same frequency, but differing in phase. (9) Elihu Thomson's safety device for cutting a transformer out of circuit in case of the failure of insulation of the transformer or of a similar fault on the line. The body of the transformer or one of its secondary terminals is earthed through the primary of a small auxiliary transformer, which has two secondary circuits connected in series and opposing each other. The free ends of the secondary winding are connected to two balls, each separated by a thin layer of insulating material from a similar ball connected to one of the primary mains. A condenser of relatively small capacity is connected across the primary balls, with its middle point connected to the points of junction of the two secondaries. If a current passes to earth through the primary of the small transformer, a spark passes between the balls, the condenser comes into action, and the fuses blow exactly as if the primary were short-circuited. (10) An automatic circuit-breaker, the invention of Messrs. Reed and Farrar, actuated by an electromagnet. By a slight modification of the design this can be used for either alternating or direct current. The paper is well illustrated by diagrams of the different devices described. B. P. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

584. *Electric Light and Power in San Francisco.* (Journal of Electricity, S.F. 11. pp. 269–279, Dec., 1901.)—A station has lately been erected by the Independent Electric Light and Power Company, and is here described. The boiler-house contains eight Babcock boilers, each of a capacity of 500 h.p. The economisers are placed immediately behind the boilers, and on a higher level; there are two rows of them, and they fill out the whole of the double flues leading to the chimney, the steam-pipes passing over the top of the flue to the engine-room. The chimney is opposite the middle of the boiler-house, two flues leading into it from both sides; it is 10 feet in diameter, and 125 feet high, being constructed of steel and lined with fire-brick. The engine-room plant includes four 1,500-kw. and one 500-kw. two-phase generators, giving their output at 500 volts and 60 cycles and 116 r.p.m.; also two 100-kw. exciters, and nine 750-kw. step-up transformers, by which the two-phase current is changed to three-phase at 11,000 volts. It is transmitted to various substations, whence it is supplied to the consumer either as direct current on the three-wire system at 110, 220, or 440 volts, or as two-phase alternating current at 115, 230, 440, or 2,300 volts, the substations containing the necessary transforming machinery. The main station, above described, is at Potrero; the power is transmitted by overhead lines for a distance of 4 miles, to a point which appears to be on the outskirts of San Francisco; after this point the high-tension transmission line is placed below the ground. Some of the substations are described, and a further article is to deal with the distributing system more fully. Drawings are reproduced, showing plan, cross-section, and longitudinal section of the main generating station, and there are several good process blocks. W. H. S.

585. *The Waterside Station of the New York Edison Company.* (Elect. World and Engineer, 39. pp. 5–14, Jan. 4; 65–76, Jan. 11; 111–116, Jan. 18; and pp. 191–194, Feb. 1, 1902.)—The new power station of the Edison Company is here described, which generates high-tension alternate current, and transmits it to the numerous substations, where it is converted by rotaries and fed as direct current into the low-tension three-wire network. The Waterside station will generate the bulk of the current used on the system, and some of the already existing stations will supplement it when required, all of them being, however, used as distributing substations. The Waterside station stands on ground 272 feet by 197 feet, facing the East River, the foundations being on bed rock. The boiler-house is 76 ft. by 267 ft. 10 in., and the engine-room is 115 ft. by 267 ft. 10 in. There are two electric cranes, having capacities respectively of 25 and 50 tons. Coal is received at a pier built out into the river, and by means of conveyors and elevators it is discharged into the bunkers, which are built over the boilers, and store 10,000 tons, or two weeks' supply. There are 56 boilers, arranged in two rows on two floors; reckoning 12 lbs. of steam per i.h.p.-hour, they will each develop 1,625 h.p. without forced draught. They were constructed by Aultman and Taylor, and are of the water-tube type. They will work at 170 lbs. pressure, and are fitted with Roney stokers, forced draught being furnished by fan blowers. The stokers and most of the rest of the auxiliary apparatus are steam-driven. There are four steel stacks, each 17 feet in diameter and 200 feet high; they are lined with firebrick for one-third of their height, the remainder being lined with red brick. The lining is carried on rings of angle iron, and an air space of 4 inches is left between the lining and the stack. Steam is delivered into a 14-inch ring, to which sixteen connections are made from the boiler-house, the boilers being also connected together by pipes which are independent of the ring. All joints are ground to a steam-tight fit, and no gaskets are allowed in any of the high-pressure piping. The condensing water is brought from the river through an intake tunnel, composed of two ¾-inch steel shells, with a space of 15 inches between them filled with concrete. Just before the intake tunnel enters the building it is divided into two parts, each 7 feet in diameter, one running under each row of engines; the water is discharged to the river through two tunnels of oval shape 8 feet high. The engines are by the Westinghouse Machine Company, and are sixteen in number; they are of the marine type, vertical, with one high and two low-pressure cylinders; cylinders 43½ inches and 75½ inches diameter, stroke 5 feet. The low-pressure cylinders only are jacketed, as superheated steam will be used; they run at 75 r.p.m., are capable of giving 10,000 h.p. with a cut-off at ⅝ths of the stroke, and are guaranteed to give their most economical load of 5,500 h.p., with a consumption of 12½ lbs. of steam per i.h.p.-hour. The shaft has a diameter of 26 inches; the cranks are set at angles of 101°, 133°, and 126°; and the flywheel has a diameter of 23 feet, and weighs 90,000 lbs. To facilitate synchronising, the speed can be varied from the switchboard by operating a motor, which shifts the weight on the governor arm. Each engine has a Wheeler surface condenser with cooling surface of 9,200 square feet. The sixteen three-phase General Electric generators give their outputs at 6,600 volts and 25 cycles, the revolving field weighs 130,000 lbs., the armature 125,000 lbs., and the foundation plates 20,000 lbs. There are three exciter sets, each consisting of a 6,600-volt induction motor coupled to a 150-kw. direct-current machine. A battery is also provided, able to excite the fields of all the generators for one hour. The arrangements of the switchboards, switches, bus-bars, &c., are fully described, everything being mounted in fireproof compartments, built up out of brick and soapstone. A large number of drawings and photos illustrate the various devices. High-tension cables are connected to all the substations; the number of feeders taken to each was based on their known loads, the maximum drop not to exceed 5 per cent., and the maximum carrying capacity for continuous load to be 250 amperes per phase. The standard copper section was therefore fixed at 250,000 circ. mils. for each of the three conductors. The company now owns 41 miles of rubber cables, and 28 miles of paper cables, for their high-tension work. The new cables are insulated with paper; each cable contains three conductors of 37 strands, and each conductor has a sectional area of 250,000 circ. mils. when each wire is laid out straight. The paper insulation is $\frac{5}{32}$ inch around each conductor, and $\frac{5}{32}$ inch for the outer insulating jacket; the lead covering is ⅛ inch in thickness, and contains from 2 to 3 per cent. of tin. The test pressure is 15,000 volts alternating current for one hour, and the insulation resistance, when laid in the subways and jointed up, is not less than 300 megohms per mile. There are now sixteen rotary converter substations on Manhattan Island. The rotaries are six-phase and of two sizes, viz., 1,000 and 500-kw. rated capacity. The former give 270-volt direct current at 187 r.p.m., and the latter by means of induction regulators give their output at any voltage between 240 and 360. Storage batteries are used in nearly all the substations. The standard battery contains 150 cells, and has a capacity of 400 amperes for ten hours. For low-tension feeders a lead-covered, paper-insulated, two-conductor concentric cable is used, each conductor having a section of 1,000,000 circ. mils., the whole being provided with six pressure wires. The conductors have $\frac{5}{32}$-inch paper insulation, and $\frac{9}{64}$-inch lead jacket. The distributors are either 350,000 or 200,000 circ. mils. single conductors, with $\frac{4}{32}$-inch paper insulation and $\frac{4}{32}$-inch lead jacket. They are designed for a maximum working pressure of 750 volts direct current. The articles contain a large number of drawings, particularly in connection with the switchboards and switches. They also include a plan and cross-section of the generating station. W. H. S.

586. *Salford Electricity Works.* (Engineering, 72. pp. 803–807, Dec. 13, and pp. 864–866, Dec. 27, 1901.)—This station supplies continuous current for lighting and traction at the usual pressures. The boiler-house, 221 ft. by 55 ft. 9 in., contains sixteen Lancashire boilers, 30 feet by 9 feet, fitted with mechanical stokers and superheaters. Each pair of boilers is directly connected to one engine besides being connected to the 14-inch steam main, which has three copper expansion bends, each bend consisting of two 10-inch copper pipes. There are two chimneys, one at each end of the boiler-house, and two economisers, each containing 800 tubes. The engine-room, which is 221 feet by 44 feet, contains eight 775-kw. dynamos, giving their output as compound-wound machines at 525 volts, or as shunt machines at 480 volts; they run at 100 r.p.m. The compound engines are of the three-crank vertical tandem type by Browett, Lindley & Co., and are described in some detail; the generators have an efficiency 95 per cent., weigh 50 tons, are connected to flywheels weighing 18 tons, and were built by Mather and Platt. There are also three balancers, each consisting of two 25-kw. dynamos running at 600 r.p.m. The travelling crane lifts 30 tons. Coal is lifted by cranes out of the barges, being delivered in boxes holding 2 tons, fitted with collapsible bottoms, and tipped direct into the bunkers, which hold in all 1,600 tons, and are placed immediately above the boiler fronts. Clinker and ashes are removed by an ash conveyor, the arrangements in connection with which are fully described and illustrated by drawings. The article contains drawings showing the plan and cross-section of the boiler- and engine-rooms, the general design of the engines, the arrangement of ash-conveying plant, and several showing the connections on the various switchboards. W. H. S.

587. *Salford Tramways.* (Tram. Rly. World, 10. pp. 692–699, Dec., 1901.) —For description of the power-house, see preceding Abstract. The track is laid with rails, weighing 103 lbs. per yard, delivered in lengths of 60 feet, and manufactured by the Leeds Steel Works. The specification for the composition of the steel was as follows: Carbon not less than 0·5 per cent., silicon not more than 0·06 per cent., phosphorus not more than 0·08 per cent., and sulphur not more than 0·06 per cent. A drawing shows a section of the rail, fishplates, soleplate, and bolts. The trolley wire is of 0000 B & S gauge. W. H. S.

588. *Bermondsey Electricity Works.* (Electrician, 48. pp. 489–493, Jan. 17, 1902.)—This station is worked in connection with a dust destructor, which is made up of six cells, and consumes 50 tons per day. Forced draught is applied to the furnaces, the pressure being created by fans; steam-jets are also fitted. The destructor gases pass through the three Babcock boilers, which evaporate 6,000 lbs. of water per hour; thence they pass through duplicate flues to the chimney, which is 150 feet high. The feed-water is softened in the Stanhope apparatus, and is stored in a tank, holding 10,000 gallons. The engine-room contains one 75-kw. and two 150-kw. continuous-current sets, which are at

present run non-condensing, and exhaust into the chimney. The balancers deal with an out-of-balance current of 50 amperes; the crane lifts 10 tons; and the cells discharge at the rate of 300 amperes for one hour. The feeders are triple concentric cables of 0·25 square-inch section, the distributors are of 0·1 square-inch section, and the arc light lines consist of twin conductor, 0·023 square-inch section. There are 70 double-carbon arc lamps, burning thirty-two hours. A plan and cross-section of the generating station are given.
W. H. S.

589. *Melbourne Electricity Works.* (Electrician, 48. pp. 524–529, Jan. 24, 1902.)—In 1891 the municipal authorities started by undertaking street lighting, and put down twenty-four Thomson-Houston 50-light arc dynamos. Subsequently they were empowered to undertake private lighting, and they bought up three companies which had existed for several years in Melbourne. In 1901 they proceeded to build a new station, which is described in the present article. The engine-room is in two spans of 37 feet, and is 96 ft. 8 in. long; it contains two 10-ton cranes. In a basement below the engine-room are placed the surface condensers with the necessary pumps. There are four 350-kw. continuous current sets, and one 200-kw. set. The surface condensers are supplied with water from a tank holding 250,000 gallons, the water being cooled by a Barnard tower, 44 feet high. The Babcock boilers, four in number, each evaporating 12,000 lbs. of water per hour, are fitted with superheaters; the economiser has 240 tubes. The main steam ring is of steel 9 inches in diameter, and the expansion pieces are also of steel. The cells have an output of 1,000 ampere-hours, and are charged by a motor-driven booster. The distributors are of 0·3 square-inch section, with 0·15 square inch for the middle wire. Some parts of the outlying districts are supplied from alternators, which were taken over by the Council when the companies' concerns were purchased.
W. H. S.

590. *Mont Cenis Power Transmission.* **Bernasconi.** (Elettricità, Milan, 20. pp. 756–759, Nov. 30, 1901.)—This installation, which is not yet completed, takes water from the Cenischia torrent at Novalese. The minimum flow of water in this is 800 litres per second, but the plant is installed to make use of 1,400, this quantity being assured by damming a lake to form a reservoir. Two stations are built in cascade to utilise falls of 415 and 444 metres. The total h.p. available is 16,000. The lower station only is now in construction, and is supplied by a temporary canal and a conduit of 72 cm. tube 1,250 metres long. The turbines are by Pictet, with horizontal axis, each giving 1,600 h.p. at 500 r.p.m. Their efficiency is 78 per cent. at full load and 62 per cent. at one quarter load. The governors maintain the speed to within 3 per cent., when the load falls suddenly from full to one-quarter load. The three-phase generators by the Thomson-Houston Company give 1,400 kw. each at 500 r.p.m. and 50 ∿, at a power-factor of 0·8. Their pressure is 3,000 volts, raised by oil-cooled transformers to 30,000 volts. The power will be transmitted to Turin, a distance of 60 km., by a pole line of 9 mm. copper wires, with a loss of pressure of 7 per cent.
G. H. B.

591. *The New York and Staten Island Electric Company.* **M. Loewenthal.** (Elect. World and Engineer, 38. pp. 1053–1058, Dec. 28, 1901.)—This Company carries out electric lighting on Staten Island, and owns 30 miles of single- and double-track railways in the district. It has grown up out of an amalgamation of other concerns. The article describes with drawings the

power-house at Livingston, which contains two 500-kw. and four 300-kw. two-phase alternators, besides one 1,000-kw. and two 250-kw. railway generators. The boilers are by Babcock and Wilcox, and some by Wickes of the vertical water-tube type are now being added. The various machines are of different makes and dates, and represent the results of a long-continued policy of absorption and expansion. W. H. S.

592. *Montgomery Water-Power Plant.* (Eng. News, 46. pp. 418–419, Dec. 5, 1901.)—Water is derived from the Tallapoosa river, 30 miles from Montgomery, Alabama. A masonry dam, 850 feet long and 42 feet high, was built across the river, giving an available fall of 40 feet without canal. There are now installed four pairs of 42-in. McCormick water-wheels on horizontal shafts, each pair generating 1,250 h.p. at 200 r.p.m. These drive three-phase Stanley generators, each giving 875 kw. at 2,000 volts and 60 ∿ , at a speed of 200 r.p.m. The pressure is raised by transformers to 30,000 volts, and the current is transmitted to Montgomery by a pole line 30 miles long with six No. 5 copper wires. In Montgomery the pressure is reduced to 2,300 volts, and the current changed from three-phase to two-phase. A reserve steam-plant of 2,000 h.p. has been installed in the town. G. H. B.

593. *A Power Plant on the Eighth Floor.* (West. Electn. 30. pp. 75–76, Feb. 1, 1902.)—The plant here described is used in a refrigerating store in Chicago, and the whole is installed on the eighth floor of the building, 90 feet above the ground level. This was necessary owing to the fact that the basement was needed for storage purposes, and it was thought that the heat of the boiler and engine rooms would interfere with the working of the freezing apparatus. The plant includes 3 double-ended marine boilers, having diameters of 10 ft. 6 in., together with an economiser, the coal being hoisted by a conveyor; and there are in the engine room three 75-kw. machines. The engines run at 275 r.p.m., and are of the horizontal cross-compound type, with the cylinders as close together as possible; the cranks are set at 180 degrees, and the reciprocating parts of the high- and low-pressure sides are equal in weight. No vibration is said to be noticeable. The load consists largely of motors, which are used in driving various machines in connection with the freezing apparatus; six elevators are also motor-driven, and the lighting of the place is also included. W. H. S.

594. *Rock Island Arsenal Power Plant.* (West. Electn. 29. pp. 333-335, Nov. 23, 1901.)—Power is derived from the Mississippi river, the head varying from 7½ to 11 feet. The dam has 42 openings, but at present only 14 turbines are put down. The vertical shafts of the turbines drive, by bevel gear, a line of shafting extending the whole length of the power house. This is subdivided into sections, so that, by removing the bolts from one or more couplings, the turbines may be run in any desired grouping. The electrical plant consists of two three-phase alternators giving 500 kw. at 60 cycles, 600 volts, with a speed of 200 r.p.m. They have hollow shafts mounted concentrically with the main shaft, and connected to it by flanged couplings. Both fields and armatures are insulated from earth. Two 25-kw. exciters are coupled to the extreme ends of the main shaft. Oil switches are employed on the switchboard, whence feeders are carried in a subway to points 604 and 740 yards distance. Eighty-two motors are employed, ranging from 1 to 75 h.p., the total power being 1,854 h.p. All the motors are of the squirrel-cage type; those of 10 h.p. or less are switched directly into the circuit, the

circuit-breaker being held by hand. For larger motors starting transformers are employed. Belt driving is used throughout, a countershaft being employed where double reduction is necessary. Oil transformers are used to reduce the voltage to 104 for the inside lighting. For the external lighting the current is transformed up to 2,100 volts, two-phase, series lamps of 50-candle-power being used. Steam reserve plant is provided, and the plant may also be run in parallel with the two-phase supply of the People's Power Company. The article is illustrated with views of the plant. A. E. L.

595. *Electric Power Transmission in Mexico.* **E. Pinson.** (Génie Civil, 39. pp. 377–388, Oct. 12, 1901.)—This paper contains a description of the installation for the transmission of power to Mexico City, from Villada and Fernandez-Leal on the Rio de Monte-Alto, a distance of 35 kilometres, and from Alameda, Chiluca and Madin on the Rio de Tlalnepantla, a distance of 26 kilometres. The alternators are driven by turbines and give current at 440 volts two-phase, which is transformed to 22,000 volts three-phase for transmission. Details are given of the lines with diagrams. H. R. C.

596. *Electrical Plants in Germany.* (Engineer, 92. pp. 528–530, Nov. 22, 1901.)—The article describes some pumping machinery, erected at the Zollverein mine at Caternberg, near Essen, which is said to be very similar to that in the Charlotte Company's mine at Czernitz. The plant of the former mine was erected by Lahmeyer. The motor developes 320 b.h.p., and runs at 60 r.p.m. The rotating part is of the short-circuited squirrel-cage type, and is mounted direct on the pump crank shaft between two horizontal pumps, the pump rods being driven direct by pins on the shaft. The armature is fed by three-phase current, and is 14 ft. 9 in. in diameter. The current is conducted down the mine shaft by two three-phase cables, each of 3 × 0·28 sq. in. sectional area, and is supplied at 1,000 volts and 25 cycles. The use of starting resistances, slip rings, collecting brushes, &c., was dispensed with by adopting the plan of starting the motor simultaneously with the generator. The dead weight of the water column is utilised by reversing the pump valves to start the pump as a hydraulic motor, and the motor receives a voltage, which rises gradually from zero to 1,000, and in this way an excessive induced current is avoided. The pump room is connected to the generating station by telephone. There is nothing at the bottom of the mine but the main switch, ammeter and fuses. The generating station contains a 300-kw. three-phase alternator, running at 150 r.p.m. In starting, a small independent steam-driven dynamo is used to excite the field, in order to ensure that the pressure of the main generator shall rise in direct proportion to the speed. This avoids any instaneous rise of pressure which would result from a direct-driven exciter at the moment when the latter reached its critical speed. When the steady speed is reached, the excitation is taken over by the direct-driven exciter. The voltage of the exciter is kept constant by a regulator on Jordan's system, the exciter being of such a size that it is capable of doing work in addition to exciting the generator, and this extra work is variable. A diagram is given showing all the necessary connections. After the plant was erected, a trial showed that the engine gave 426 i.h.p. at 142 r.p.m., while the pump delivered 673 gallons per minute against a head of 1,350 feet at 60·2 r.p.m. The actual power utilised in the water column was, therefore, 278 h.p., showing an efficiency of 65·5 per cent. overall.

The central station at Essen is also described. It contains three 1,000-kw.

and two 500-kw. three-phase machines, generating 5,000 volts at 94 r.p.m. The barring gear is worked by a motor, and by noting the current taken by this motor, the state of the friction surfaces of the engine may be at once seen. Essen is situated in the centre of the Westphalian mining and steel industries, and the load consists to a large extent of motors, which are used in engineering works of various descriptions. These motors are very largely of the asynchronous type, and the power factor over the whole system is said to be 0·7. At the three-phase station, erected at Bockenheim, near Frankfort, in 1892, the power factor is now said to be 0·55, and this shows the effect of many motors of an old type, which are still working on the network. The article concludes by stating that in Germany the number of rotary converters is very small as compared with the number of motor-generators, even where tramway work is concerned. W. H. S.

597. *The St. Louis Transit Company.* (Street Rly. Rev. 11. pp. 813–824, Nov. 1901.)—The street railway companies of St. Louis were consolidated in 1899, and since then two new power-houses have been built to replace eleven which then existed, four of which were cable power-houses. The new stations are called respectively the Central and the Northern. The whole area covered is about 12 miles long by 7 miles broad. The Central station has an engine-room 220 feet by 100 feet, and contains four 2,250-kw., three 1,500-kw., and three 650-kw. direct-coupled railway generators, giving their outputs at 550 volts. The speed of the three latter machines is 140 r.p.m., and of the others 75 r.p.m. There are two boiler-houses; the one is 278 feet by 34 feet, containing 14 Stirling boilers, each evaporating 11,000 lbs. of water per hour, and delivering steam into a main 16 inches in diameter; the other is 316 feet by 50 feet, and contains 16 boilers, which each evaporate 20,000 lbs. of water per hour and deliver into a steam main 20 inches in diameter. Each boiler-house has a separate pump-room, placed between it and the engine-room; here are installed steam purifiers, heaters, boiler-feed pumps, tank pumps, cold- and hot-water meters, &c. The southern boiler-house has three steel chimneys, 7 ft. 6 in. in diameter and 160 feet high; the other has one only, which is 202 feet high and a diameter of 14 feet. The joints are butt joints with inside and outside straps; the details of construction, and the thickness of plates, joint straps and rivets are fully set out in the article. The municipal authorities own the monopoly of water supply; hence six wells have been sunk, giving about 100,000 gallons of water per 24 hours, and twelve cooling towers were erected, each 20 feet in diameter and 32 feet high. About 7,000 tons of coal can be stored. In order to meet temporary emergencies the three 650-kw. steam-driven sets are used as boosters; and on one line which has a very heavy traffic for a very few days these three machines have been run in series with the bus-bars, and the pressure raised as high as 1,800 volts. The Northern power station is not yet complete, but will contain two 2,250-kw. railway generators and two 1,200-kw. three-phase alternators, all running at 75 r.p.m. All engine-rooms have 75-ton three-motor cranes. The boiler-house at this station has 16 boilers, each rated at 400 h.p., and fitted with chain grate stokers. The general design is similar to that of the Central station. The Siegrist lubricator system is used, by which oil is supplied under pressure to all the engine cylinders and bearings, the latter of which are water-jacketed. The piping necessary for this system is shown in plan and elevation in one of the drawings. A substation is placed at Delmar, about 5 miles west of the Northern Station and 3 miles north-west of the Central station. This substation is 45 ft. 6 in.

broad and 115 ft. 9 in. long, and contains four 600-kw. rotary converters and thirteen 250-kw. transformers, transforming from 6,000 to 380 volts. A booster will also be erected as soon as the arrangements are complete. The article contains drawings showing plans of the two power-houses, a section of one of the boiler-houses and of a coal-storage building, the arrangements of the Barnard cooling towers, and of the feed piping, besides the connection for the Siegrist lubricator system, already mentioned above. W. H. S.

598. *The Zossen Marienfelde Polyphase Railway Trials.* **W. Reichel.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1369–1377, Sept. 28; pp. 1414–1419, Oct. 5; and pp. 1457–1463, Oct. 12, 1901. See also Elect. World and Engineer for Sept. 7, Oct. 5, 12, 19, 26; and Nov. 2 and 9, 1901.)—These articles contain a description of the experimental trials which have been made by Siemens and Halske on the polyphase railway between Zossen and Marienfelde, a distance of 14¼ miles, with grades ranging up to 1 in 184, and a minimum radius of curvature of 3,280 feet. Experiments were first carried out with a view of determining the effect of wind pressure, as the formulæ in ordinary use give figures which are much too high in the case of speeds exceeding 62 miles an hour. An apparatus constructed on the principle of the anemometer, and driven by an electromotor capable of giving 200 h.p. for short periods, was therefore made. The arms were about 10 ft. 6 in. long, and at the ends of the arms the bodies to be rotated were attached. After some preliminary trials, a body having its front and back ends of a more or less paraboloidal shape was used, the air resistance being then found to be only about one-third of that opposing a flat-ended one. It was finally determined that to propel a car with its end shaped in this manner, and estimated to weigh 94·5 metric, or about 93 British, tons, when carrying the full complement of 50 passengers at the rate of 125 miles an hour, would require 1,000 h.p. The author gives figures showing the way in which the weight is distributed between the various electrical and mechanical portions of the car. Several drawings are given showing the construction of the car and of the trucks for the same. The car is 24 yards in length, the body being carried on longitudinal girders joined together by top and bottom plates formed of U and flat iron connected by heavy iron sheets reaching from the lower edge of the car body to the lower ends of the windows. There are two six-wheeled trucks, and the car body is attached to each truck frame by means of a projecting pin, without the intervention of springs. The truck frames themselves rest primarily upon adjustable spiral springs, from which the load is transferred to long flat springs which rest on the journal boxes. The wheels are 49 inches in diameter, and the motors are mounted direct on the two outer axles, the middle one in each truck being left free to provide space for the supporting frame for the pin in the car body, and for the braking apparatus. A Westinghouse automatic brake is employed, braking the wheels on both sides. A hand attachment is provided, by which the motorman can apply about 80 per cent. of the brake power. The transformers transform from 10,000 volts to 1,150 volts, though the pressure available at starting is 1,850 volts. Each truck has two motors, there being, therefore, four in all for the car, each furnishing normally only 250 h.p., though capable of an output of 750 h.p. in order to obtain sufficiently rapid acceleration. Metallic resistances are used for regulating the speeds; to facilitate cooling these are enclosed in flat cases, placed along the two side walls of the car. In order to make the connections between the resistances and the controllers as short as possible, the controllers are also distributed

along the sides of the car, and are operated by compressed-air mechanism, which is also employed for working the switches. The variation of the voltage obtained from the transformers is effected by varying the connections from star to delta. Each of the two transformers has its three legs laid flat in the direction of the length of the car; in this way it is possible to set up circulating air currents for cooling. The primaries are permanently connected in star fashion. The connections between the switches and transformers consist of bare wire mounted on high-pressure insulators. The air pumps are placed beneath the motorman's platform, and are operated by current supplied by special small transformers. The electrical equipment really forms two distinct units, each one containing two motors, two rheostats, two main switches, two fuses, one large transformer with delta and star switches in the secondary, and primary high-pressure switches, as well as a high-pressure protective device, an air-pump and small transformer with fuses, a trolley, an air reservoir, and a motorman equipment with compressed-air switches and measuring instruments. In case of one equipment being disabled the pressure in the primary circuit of the motors will be raised.

Motors.—The motors have six poles, and a normal speed of about 900 r.p.m. The stator core is undivided, owing to the numerous connections which would be required if it were made in two halves. The case is of steel, and, to facilitate cooling, is made smooth inside and closely fitted to the stator core, both it and the bearing covers being made in two parts to admit of removal for repairs. To the lugs of the lower bearing covers flat iron pieces are bolted, which transmit the turning moment of the motor to the truck by means of springs. No further spring attachment is employed, as it was considered likely to lead to trouble at the higher speeds contemplated. As the heating of the core is mainly in the primary, large radial depth was required to ensure low saturation. To economise space without sacrifice of turning moment the primary was therefore made the rotor, the current being led to it through eight carbon brushes and three collector rings. The rotor winding is of the continuous-current bar type, which enables wire bands to be employed to provide against the high centrifugal tension. *Controller.*—The starting rheostat is divided into 29 steps, 4 primarily to cut in the motor, and the other 25 for the gradual variation of its speed, each step cutting out 20 h.p., the motor output being 750 h.p. at starting, and 250 h.p. at full speed. This can be effected without serious sparking. For each phase of each motor there is one of the flat cases previously referred to, 3·74 feet in length, containing the four starting coils, and another, 5·12 feet in length, for the other 25 coils, the height and width of each being 4 feet and 5·8 inches respectively. They are of angle iron, bolted to the top and bottom car girders, with sheet-iron, shutter-like, ventilated covers. The coils are of "Kruppine" of 1·75 in. by 0·078 in.-section, supported on porcelain insulators, the lower attachments being so made as to allow of expansion. For each phase of each motor there is a controller cylinder parallel to the length of the car and beneath the large cases. The contact-pieces are of bronze and removable, the *a*, *b*, *c* connection being employed to avoid the necessity of 25 regulating contacts for each phase. On the first contact the four motors are cut in in succession instead of simultaneously, which saves resistance material, besides throwing the load on to the station more gradually. The controller is actuated by a differential arrangement consisting of a pair of large and small oppositely acting air cylinders, the smaller one always being under pressure. This gives very complete control to the motorman without taxing his strength. *Switches and Fuses.*—To divide the current and to enable a damaged motor to be cut out, each motor has its own mean-pressure switch, and a safety fuse for each phase. The switch has a double break of 5·4 inches in each phase, the six contacts being set in a circle with the actuating air cylinder in the centre. A snatch-hook comes into action when the switch is closed, and, when breaking, maintains contact until the air piston has reached its lowest position, thus giving a quick break. The arc is drawn in a narrow insulating tube, and extinguished by a metal cooling ring. The transformer switches, as well as those for the motors, are built for both delta and star connections, one transformer switch being provided for each connection, for each unit of the equipment, so that there are eight switches in all for the four motors. The high-pressure fuses are enclosed in four tubes contained in one large tube of mica. The high-pressure switches differ from the mean-pressure ones in being arranged in sets of three, one-half of the switch being below, and the other half above the roof of the car. The compressed-air arrangement by which they are operated is of the same general character as for the mean-pressure switches. *Compressed-air Mechanism.*—The air-tanks for the brakes and the switches are located respectively in a corner of the floor of the platforms at each end of the car, and on the ceilings above them, a pressure of 8 atmospheres being employed for the brakes, and 4½ atmospheres for the switches. The tanks at each end of the car are connected by two equalising pipes, and the system is operated from a table on the front of the platform. *Current Collection.*—The trolleys are of the bow type, as shown in the accompanying illustration. It was considered inadvisable to allow any crossings over the line, both because the wires might be touched from the bridges, and because they would necessitate the lowering of the trolleys, which would be undesirable at such high speeds. This decision gave the designers unlimited space above the roof. The trolley pole is formed of two telescoped Mannesmann tubes 7·8 inches in diameter, the lower one being firmly fastened to the floor of the car, and passing through a sleeve bearing in the roof. By means of a hand-brake operating a double set of gears the mast can be revolved by the motorman, and it can be held in its lower bearing by a wedge. At the upper end of the lower tube is a cast-steel flange, surrounded by a hard

rubber sleeve, and to this flange the tube carrying the collector rings is attached. Three contact springs press against these rings as shown, and are attached to hard rubber posts carried by an iron support fixed to the roof of the car. The upper tube is fitted into the hard rubber sleeve on the lower one, and fixed by screws. The trolleys are carried by three revolving sleeves 1 m., or 3·28 feet, apart, on this tube. The enormous wind pressure is prevented from causing the trolleys to leave the wire, both by means of springs and by the use of equalising plates, as shown in the illustration, the wind pressure on which opposes that on the trolley. The collectors are detachable, and of steel tubing as usual. The trolleys are electrically connected to bronze cups carried on the bell insulators above the axes of the trolleys. From them the current passes by contact springs, through lightning arresters of the ordinary fork type, to the collector rings. There are two trolley poles on each car in order to divide the 200-ampere current. *The Trolley Line.*—The trolley wires are carried on wooden poles 35 m. apart, and 2¼ m., or 7·38 feet, from the centre of the track, by means of the link suspension shown in the illustration; they are 1 m. apart, with the lowest wire 5½ m., or 18 feet, above the surface of the rails. The wires are doubly insulated, each insulation alone being capable of withstanding a pressure of 12,000 volts. One of these is the hard rubber chain at the top and bottom of the bow-shaped iron support which carries the three trolley wires. The second consists of a conical iron bolt 200 mm., or 7·8 inches, in length, surrounded by a hard rubber sleeve 5 to 6 mm., or about 0·2 inch, in thickness. The insulator, also of rubber, is screwed into a thread about 2 inches long at the upper end of the sleeve. The wires are of hard-drawn copper with a section of 100 mm., or 15 square inches, and a conductivity of 97 per cent. of that of chemically pure copper. The 23 kilometres, or 14·26 miles, of line are divided into sections of 1 km., and each section is anchored in the direction of its length. The sections are connected by easily removable wires in the place of section switches. Between any two sections the trolleys leave the wires for a distance of about 10 m., or nearly 33 feet, but as the two battery poles are 17·64 m., or nearly 58 feet apart, the car is never without current. In case of a broken wire the current-carrying wire will be grounded by a device shown in the illustration. At each point of support of the trolley wires is clamped a loop of 8 mm. copper wire, which, if the break occurs in the wire, will be pulled against a copper wire, shown in the illustration, which terminates above in a spring, while its lower end is attached to the rails. Copper cable rail bonds are employed. The rails are connected by a wire to the neutral point, and are earthed by ground plates at intervals of a kilometre. The feeders are of bare wire where possible, with a section of 50 sq. mm. Where cables have to be used the section is 70 sq. mm.

The paper contains a detailed description of the preliminary tests of the electrical equipment. The author calls attention to the fact that it is impossible for the motorman to come into contact with any of the wires, even the insulated ones. G. W. DE T.

599. *Croydon Electric Tramways.* (Electrician, 47. pp. 899–902, Oct. 4, 1901.)—The energy is supplied by the Corporation at the rate of 2d. per Board of Trade unit to the British Electric Traction Company, who have a lease for the undertaking. When completed the total length will be, expressed as single track, 17½ miles. The chief interest is in connection with the Quin system of protection, which is being installed throughout. It primarily consists of an automatic maximum and minimum cut-out in each section of the

line. These sections are separated by the usual insulators. From the negative bus-bar in the Quin pillar, a shunt is taken to the far end of the trolley wire, and connected to it at the sectional insulator. The current through this shunt coil keeps the automatic switch closed, but should the trolley wire break, or the current fail, the switch which connects the feeder to the trolley wire opens, and the section is completely isolated. If a telegraph or telephone wire comes in contact with the trolley wire there is further protection, a series coil is placed between the feeder and the trolley wire, and this acts on the switch, disconnecting the circuit should an excess of current flow through it. The Corporation plant consists of two 300-kw. Belliss-Thomson-Houston sets. A third set of 600 kw. is to be added.

W. W. H. G.

600. *Wigan Tramways.* (Tram. Rly. World, 10. pp. 607–613, Nov., 1901.)—There are at present four miles of track, which are laid with rails, weighing 107 lbs. per yard, on a bed of concrete 8 inches deep, with 2 inches of gravel on the top. The rails are 7 inches deep, and have a base 7½ inches wide; the depth and width of groove are $\frac{15}{16}$ inch and ⅞ inch respectively. A double trolley wire has been used of No. 000 B. & S. gauge, with three feeders, each of 0·3 sq. in. section. The power station is also described. [See also Abstract No. 1207 (1901).]

W. H. S.

601. *New Bedford and Onset Street Railway.* (Street Rly. Rev. 11. pp. 879–887, Dec., 1901.)—This line is about 23 miles long, and is supplied with power from stations at Wareham and New Bedford, which are near the respective ends of the line. The Wareham station contains a 300-kw. and a 200-kw. generator, both belt-driven; also a 250-kw. direct-coupled unit. The New Bedford power-house has more modern plant, consisting of two direct-coupled 800-kw. machines running at 100 r.p.m.; there are in addition two older belt-driven machines. The generators are wound for 750 volts, but current is generally supplied at about 650 volts, for which pressure the motors are wound. The track is mainly constructed of 70-lb. rails in 60-feet lengths, placed on chestnut ties spaced 20 inches centre to centre; Crown bonds are used, and Weber rail joints. The trolley wire is of No. 00 gauge, and is supported partly by brackets and partly by span wires, wooden poles being used in the country, and iron poles in the towns. The article contains several drawings, showing the plan of the station at Wareham, some of the piping arrangements, and a cross-section and plan of the carshed at Wareham. The carsheds are protected by sprinklers in the roof, and by sprinkler pipes under the floor between the pits for fire-insurance purposes, and the pits are heated by steam pipes.

W. H. S.

602. *Brighton Tramways.* (Tram. Rly. World, 10. pp. 700–704, Dec., 1901.)—A plan is given showing the routes that are opened; there are 6½ miles in all, mostly double track. The rail used is 6 inches deep, and 7 inches across the base; weight not stated. They are in 36-feet lengths, with a small proportion of 30 feet. A drawing shows a section of the rail and fishplates; and another drawing shows the construction of the joints, in which a 6-inch steel girder transverse sleeper is laid under the soleplate, and crossing the track, connects together the rails on either side; bolts pass through the base of the rail, the soleplate and the top flange of the sleeper. The transverse sleeper is buried in the concrete, which is 12 inches deep at these points; over the rest of the track, the concrete is 6 inches deep under wood paving of

American red gum. The trolley wire is of No. 000 gauge. The tramway power-house adjoins the lighting station, and contains one 825-kw. and two 175-kw. machines. W. H. S.

603. *The Milan-Monza Tramway.* **G. Semenza.** (Street Rly. Journ. 18. pp. 515–518, Dec., 1901.)—The line is 10¼ miles long, including 2 miles of city track, belonging to the Milan tramways. From the centre of Milan to the city boundary at Loreto, the track is laid with 93-lb. girder rail; the rest of the track is laid with 53-lb. Vignole rail. The rail bonds consist of two copper wires brazed to the foot of the rail. The brazing is done by making a coil at the end of the bond, and using a hand blower. The author says that an experience of four years in Milan shows that the bonds are thoroughly good, and electrolytic corrosion is so far unknown. Two No. 00 trolley wires constitute the overhead conductors. The line is supplied with power at its middle point from the Paderno-Milan transmission system. Eighteen bare copper wires of No. 00 gauge convey current at 42 cycles and 15,000 volts into the substation, where the pressure is reduced by transformers to 330 volts, and then transmitted to two rotary converters of 200-kw. capacity. The periodicity has been found to be rather high for the satisfactory working of rotary converters. There is also a battery of 280 cells, having an output of 800 amperes for one hour; the positive plates are of the Majert type, and the negative plates of the Pescetto type. The article contains a drawing showing a section and plan of the converter station, and also a section of the car used on the line. W. H. S.

604. *Milford, Holliston and Framingham Street Railway Company.* (Street Rly. Journ. 18. pp. 503–508, Dec., 1901.)—The system includes in all about 40 miles of track. The power station is at Milford, and supplies current both for lighting the town and for the purposes of the railway. The boiler-house contains five tubular boilers, and the engine-room has two belt-driven 125-kw. alternators, giving their output at 2,400 volts and 66 cycles, as well as two direct-coupled railway generators, respectively of 225-kw. and 325-kw. capacity. There are three substations, two of which contain batteries, and the third a rotary converter of 125 kw. The rotary converter substation is connected to Milford by a high-tension transmission line, consisting of No. 4 B. & S. aluminium wire, the power being transmitted at 10,000 volts. There is also a feeder for the direct-current distribution, consisting of aluminium wire, having a sectional area of 360,000 circ. mils., and all the aluminium conductors are carried on the regular trolley poles. The track consists partly of 9-inch 90-lb. girder rail, and partly of T-rail of weights varying from 50 to 60 lbs. W. H. S.

605. *Barmen Rack Railway.* **Daubner.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 8–17, Jan. 4, 1902.)—The rack railway was opened in 1894, and has become the nucleus of an extensive system of tramways and a light railway, all of which are supplied from a power-house in the lower terminus of the rack railway. The generating plant consists of 5 water-tube boilers of 181·7 sq. m. heating surface each and 5 Elephant boilers of 113 to 130 sq. m. heating surface. The feed water is taken from four wells and passed through a Derveaux water-softener. There are two direct-connected sets of 1,000 h.p. each and two of 500 h.p. The larger engines are of the horizontal tandem type with atmospheric exhaust and trip valve gear. They drive 12-pole shunt-wound generators. The smaller engines are of the vertical cross-

compound type with piston valves for the high-pressure cylinders. They drive internal pole shunt-wound machines. A battery of 260 cells of 750 ampere-hours capacity is used to take up the irregularities in the load. A motor-booster is employed for charging. The power-house feeds in all 35·55 km. of line, including 1·65 km. of rack railway and 4·5 km. of light railway running from the end of the rack section to Ronsdorf. The gauge is 1 m. throughout. The rack railway has a maximum gradient of 1 in 5·4, and a mean gradient of 1 in 9·7. The rack is of the Riggenbach type with 75 mm. pitch and 90 mm. breadth of teeth. The light railway has a maximum gradient of 1 in 25. On these two lines, which are the oldest in the group, shunt motors have been employed with good results. The energy required for an upward journey of a 14-ton car is 11-kw. hours, of which 5·6-kw. hours are returned to the line on the downward journey. The maximum speed allowed is 9 km. per hour. The 14-ton cars carry each two 60-h.p. motors, the 11-ton cars one 85-h.p. motor. In addition to the braking action of the current, the cars are provided with grooved brake drums on the pinion shafts. These can be braked either by hand or automatically on exceeding a certain speed. There are also ordinary brakes on the running wheels. The light railway is worked by cars having two 25-h.p. shunt motors. Goods traffic is provided for by two electric locomotives having each two 60-h.p. shunt motors. The article is illustrated by numerous photographs and diagrams. A. E. L.

606. *Nogent Tramways.* **T. Pausert.** (Écl. Électr. 30. pp. 133–143, Jan. 25, 1902.)—The earlier portions of these tramways, dating from 1887, were worked by compressed air, but this system was not found to lend itself to further extensions, and was abandoned in favour of electric working. The system at present consists of 50 km. of lines serving 20 communes in the vicinity of Paris, with a line running into the city as far as the Place de la République. The power-house is at Vincennes, and contains eight multi-tubular boilers having a heating surface of 106 sq. m. each, and suitable for a pressure of 17 atmospheres. They are capable of evaporating 2,500 kg. of steam per hour each. Reducing valves are employed to reduce the pressure to 8 or 9 atmospheres for the engines. Town water is used for feeding the boilers, and is softened by means of a "Desrumeaux" softener. A deep well is also provided as a stand-by. The engine-room contains two 500-kw. generators and two of 325 kw. The 500-kw. generators are driven by compound Corliss engines, having 600 and 950 mm. cylinders with 1,080 mm. stroke, running at 95 r.p.m., and the smaller ones by single-cylinder engines. The engines exhaust either to the atmosphere or into jet condensers, the water being passed into a cooling tower and used again. The generators are overcompounded to give 500 volts on open circuit and 600 volts at full load. A set of three negative boosters, driven by a 15-kw. motor, are employed for the return cables. The switchboard is provided with two positive bus-bars, allowing different feeders to be supplied at different pressures. The feeders, of 300 and 400 sq. mm. section respectively, are lead-covered and armoured, and are buried directly in the ground. The trolley wires, 9 mm. in diameter, are suspended 7 m. above the ground, and are divided into sections of 1,500 m. connected through switches. They are carried by brackets on steel poles. The track is laid to standard gauge of 1·44 m. The rails are partly of the "Broca" section, weighing 48 kg. per m. with Falk cast-welded joints laid on concrete, and partly of the "Vignoles" section, weighing 25 kg. per m., laid on wooden cross sleepers and doubly bonded with "Chicago" bonds. For a length of 3 km. in the suburbs of Paris, the

trolley is discontinued, and the cars fed on the side-slot system already in use on the other Parisian lines, while in the city itself the cars are driven by accumulators. The cars for city service measure 11·25 m. overall and carry 78 passengers. They have roof seats with a canopy. They are mounted on bogies of 1·22 m., wheel base spaced 3·87 m. from centre to centre. Each car carries two motors of 45 h.p. The battery consists of 210 cells weighing 18 kg. each, and is charged in about nineteen minutes from the trolley wire. For the suburban service the cars are without accumulators, and carry 52 passengers. They are mounted on four-wheel trucks and carry two motors of 35 h.p. Air and hand-brakes are used. At Maltournée, 8 km. from the power-house, there is a 400-ampere-hour buffer battery provided with a booster for charging. A. E. L.

607. *Hamburg Tramways.* **H. Vellguth.** (Street Rly. Journ. 19. pp. 1–12, Jan., 1902.)—A complete description of these tramways is here given. The track is laid with 106-lb. girder rails; the groove is 1¼ inches in width and depth, the inner flange is $\frac{9}{16}$ inch wide, and the head of the rail is 2⅜ inches wide, the base being 5⅛ inches across, and the depth of the rail 6 inches. The construction is unusual in many ways, noticeably in that no cross-ties of the usual kind are used, but the rails are joined together by a flat rod of peculiar section, which embraces the rail bases by means of extensions, and is secured by wedges. The fishplates are also of special section, and are carried round beneath the base of the rail on both sides. All these features are illustrated by drawings, which also show the standard track construction in streets with and without concrete foundation. It was found that the treads of the wheel-tyres wore more rapidly than the flanges; the expedient was therefore adopted of having the outer rails with grooves $\frac{9}{32}$ inch deep on all curves having radius of less than 33 yards. At these points the outer wheels therefore run on the flanges, and no case has occurred where a car has jumped the rails. Even now the wear on flanges and treads is not equalised, and it is intended to adopt the shallow-grooved rails on the outers of all curves having a radius of less than 80 yards. These shallow rails are also used on built-up crossings. On curves where the shallow-grooved rails are used the gauge is made somewhat tighter, the rule being to make it 1,432 mm. instead of 1,435 mm. The rails are double-bonded with copper bond wire 0·35 inches in diameter. More than half the track is laid on a ballast of coarse gravel or broken stone, of which the latter is preferred. Concrete foundations have only been used where the entire street had such a foundation, and then a layer of asphalt $\frac{11}{16}$ inch in thickness is placed between the rail and the concrete. The switch tongues, which are of Siemens-Martin steel, are 13 feet long and operated by hand. The trolley poles of Mannesman steel are 40 yards apart. On one of the main streets some double-bracket poles are used, though they appear to be placed at the side of the road which borders the harbour. These brackets are 28 feet long, and, being of ornamental design, the poles are said to have cost £500 each. The trolley wire is No. 0 in the suburbs, and No. 000 with a figure 8 section in the town. Recently a wire having a rectangular section, but rounded at the four corners has been introduced. The thickness of this wire is $\frac{5}{16}$ inch, and the cross-section is 158,000 circ. mils. The tension on a No. 0 trolley wire is 400 kg.; when the warm weather approaches small pieces are cut out of the trolley wire at convenient points, and these are replaced in colder weather. The trolley wires on the streets with heavy traffic are replaced every three years. Power is purchased from the town electric lighting company, which owns all

the connecting cables, and is said to be responsible for any damages due to electrolysis. There are in all 33 feeding-points. The rolling stock is also described, and the passenger receipts analysed. W. H. S.

608. *Chicago and Joliet Interurban Railway.* **A. S. Kibbe.** (Street. Rly. Rev. 12. pp. 4–13, Jan., 1902. See also West. Electn. 29. pp. 218–219, Oct. 5, 1901.)—This line consists of 70 miles of single track, with no grades exceeding 5 per cent., and few sharp curves. The rails vary from 40 to 73 lbs., being chiefly 70 lbs. per yard, and are bonded with one "Protected" bond equivalent to a No. 0000 wire at each joint. Most of the track is laid on the highways, on cross-ties, ballasted with limestone 6 inches deep below them, and paved in towns. Span construction is used wherever possible. The trolley wire is No. 000; the feeders are of aluminium cable, part working at 15,000 volts, part at 2,300, and the remainder at 600. The only difficulty with the aluminium cables has lain in their high coefficient of expansion. The generating plant at Joliet consists of two G. E. alternators of 750 kw. each at 60 cycles per sec., 2,300 volts, driven by 12 turbines operated by the River Desplaines. The nearest substation (1 mile) is fed at 2,300 volts; two others, at 12 and 24 miles respectively, are fed with current transformed up to 15,000 volts. On account of the high frequency, induction-motor generators are used in the substations in preference to rotary converters, which are unstable under these conditions. In the distant substations the current is stepped down to 550 volts for the motors. Large storage batteries have been installed at the substations to obtain the best results from the water-power, and the fluctuation of the motor-generator loads is only about 10 per cent. Motor-driven boosters with compound winding are used to charge and discharge the batteries. Commodious buildings have been provided to house the plant. Cars 20 and 30 feet long are used for local services. For interurban traffic, the cars are 36 feet long, on Brill trucks. The wheel base is 6 feet, and the gauge standard. Christensen air-brakes are fitted. Each car is equipped with G. E. 67 motors geared to 40 m.p.h. Normally the cars, which weigh 50,000 lbs. loaded, make the 30-mile run in 80 minutes, including 20 or 30 stops, and use 75 to 90 units. The traffic arrangements are described, and the article is fully illustrated. A. H. A.

609. *Rail Feeder Construction in San Francisco.* **S. L. Foster.** (Street Rly. Journ. 19. pp. 25–26, Jan., 1902.)—The main station is situated on a street having a double tramway line on it, constructed of 62-lb. girder rails. Exclusive of the current brought back by the earth, which consisted mainly of a bonded 20-inch cast-iron salt-water pipe, and an unbonded 30-inch similar pipe, all the current was brought back to the power-house along the double-track road, the joints being bonded with three No. 000 bonds. The rails were connected to the negative bar by four copper bars, each of 1,000,000 circ. mils. section. As the load increased in the process of time from 1,200 kw. to 5,000 kw., the loss in rails and cables became excessive. About 300 yards north and south of the power-house there are two points where the traffic becomes congested, and though the total section of the return paths from these points amounts to about 160 square inches of steel, or about 16 square inches of copper, the maximum current of 10,000 amperes was very uneconomically carried. The copper cables, too, became extremely hot, and at times the sleeve connections were partially unsoldered; at times of heavy load, they were only saved by the chilling effect of streams of compressed air. Moreover, alleged electrolytic destruction of lead service pipe occurred

near the station. It was, therefore, determined to increase the capacity of the return conductor on the street facing the power-house. For this purpose a nest of fourteen old 45-lb. steel tramway rails were laid in a trench along this street for about 600 yards, connecting the points above-mentioned, and where this line of rails passed the power-house it was connected to the negative bar by two copper conductors 1 inch by 5 inches in section. The successive rails of each line were connected by a riveted lap-joint 12 inches long, the joint being also bonded by two copper tubes, $\frac{11}{16}$ inch in outside, and $\frac{3}{8}$ inch inside diameter. The 1 inch by 5 inches copper bars were 10 feet long, and were connected together by lap-joints 7 inches long, and held by eight $\frac{5}{8}$-inch steel bolts. Further details of the construction and of the method of making the various connections are given at length, accompanied by drawings. The current density in the return conductors has now been reduced to a maximum of 500 amperes per square inch. Careful tests were carried out before and after the alterations were made, and it has been found that there is a saving in the power required amounting to 2¼ per cent. of the total output of the station. The results were to some extent improved by the fact that after the old rails were connected up, the fishplates and bonds were removed from the double track passing the power-house, and the joints were cast-welded. The average C^2R loss in the return conductors is stated to be only 21·3 per cent. of its previous value, and the estimated saving per annum amounts to 78 per cent. of the total cost of the work. W. H. S.

610. *Surface-Contact Tramways at Wolverhampton.* (Tram. Rly. World, 11. pp. 65–76, Feb., 1902.)—These tramways have been equipped on the Lorain system. At present one mile of track is open for traffic, but the remaining ten miles will be opened in the course of the next few months. The cost of track construction has been about £5,500 per mile, and in addition the cost of the surface-contact system has been about £1,800 per mile, making a total of £7,300. The gauge is 3 ft. 6 in., and the rails weigh 100 lbs. per yard, a drawing being given showing their section. The insulated cable, which is of 0·05 square-inch section, is brought up through the concrete at intervals of 10 feet, this being the distance between the various contact boxes. The cables are laid on the solid system in bitumen; but ordinarily the Lorain Company is said to prefer a drawing-in system. The contact box consists of a base of insulating material, known as reconstructed granite, and a metallic cover, the main portion of which is of iron, and the central part at the top is of specially hardened non-magnetic steel, adapted to resist the wear of the collecting shoe. The contact is made between two carbon surfaces in a hermetically sealed chamber, the rising contact being connected to the feeding cable by a thin strip of hard rolled copper, about 1½ inches wide, folded upon itself. After the car has passed, the contact is broken by the force of gravity. Three drawings are given, showing sections of the contact box. A diagram is reproduced, showing the method of wiring the car, necessary for the Lorain system, and provision has been made for taking current from an overhead line, in case the cars should be run on any such section. The energising coils for the magnet carried on the car have a compound winding, one being in series with the motors, and the other being a shunt winding of the normal tramway voltage. Six cells are carried on the car, which are charged, when necessary, by closing a switch, which places the cells in series with the motor. The cells are used at the moment of starting the car from the car-shed. Three drawings show the arrangement of the collecting shoe and magnets on the car. Power is provided from the town electricity works, and two units of 825-kw. capacity have been installed for the purpose, the engines being by Willans and Robinson, and the generators by the Electric Construction Company.

W. H. S.

611. *Rearrangement of Power Generating and Distributing Scheme at Worcester, Mass.* (Street Rly. Rev. 12. pp. 33–35, Jan., 1902.)—This paper deals with the problem of economically distributing power over street-railway systems, formed by the consolidation of several independent systems. The case in point is the system of the Worcester Consolidated Railway Company, of Worcester, Mass., which comprises the routes operated previously by seven independent companies. The total mileage of the Consolidated Company is 130 miles of electric railway track, in and about the city of Worcester. It is pointed out that latter-day knowledge would probably advocate for such a system a high-tension alternating-current distribution from a central power-house, with transforming and converting substations near the centres of the outlying loads. The saving to be effected by such an alteration has, however, to be set off against the losses of the original outlay on the various local power-houses, and in this case a careful investigation of the figures did not warrant such a change. What is being done is a rearrangement of the power and storage battery plants, whereby three of the old power plants are wiped out, and the storage batteries moved to points where they afford the greatest assistance in working the combined system. A new 3,000-h.p. Allis engine direct-coupled to a 2,000-kw. General Electric direct-current generator is being added to the main power-house plant at Worcester, and the plant from the discarded stations is in part being moved, to augment the output from the stations which have been retained, and in part sold. The equipment and output capacity of each of the power-houses is given in detail. A description is given of the improvements in the track and cars introduced by the new company, the latter being mounted on Laconia No. 8 B high-speed double trucks, with the patented "perfectly cushioned swing bolster."

J. L. F. V.

612. *Electrical Equipment of Palmer's Shipbuilding Works.* (Engineering, 72. pp. 607–609, Nov. 1, 1901.)—These works were supplied with power by a multitude of small engines, scattered about the shops. These engines have now been replaced by motors; but the long lengths of shafting, and the numerous belts and pulleys have been practically retained in their entirety. Under the old system Lancashire boilers were placed at various points, and supplied steam to an extensive range of steam pipes. The present power plant is placed in an independent building, and contains four Lancashire boilers, and two 750-kw. three-phase alternators, supplying current at 440 volts. The alternators have flywheels weighing 22 tons, and run at 160 r.p.m. Two 25-kw. steam-driven exciters are also provided. There are in all about 80 motors in use, ranging from 50 h.p. downwards, all being of the polyphase induction type. A long list is given of these motors, showing the various machines driven, the method of driving adopted, and the various shops in which the different motors are placed. The smaller motors up to 10 h.p. are started by coupling them direct to the 400-volt mains. The larger ones are started by an "autostarter," which consists of a double-throw switch, worked in conjunction with a pair of small transformers. With the switch in one position, the motors receive current at a reduced pressure through the transformers, which have a series of loop wires from the winding so that the starting pressure may be suitably adjusted. With the switch in the other position, the motor is thrown, after the start, on the supply mains direct. The installation has been carried out by Clarke, Chapman & Co., in conjunction with the Westinghouse Company. W. H. S.

613. *Electrical Equipment of the Manhattan Elevated Railway.* (Elect. World and Engineer, 39. pp. 76–78, Jan. 11; 117–119, Jan. 18; and pp. 153–155, Jan. 25, 1902.)—The first two of these papers traverse ground already covered in Abstract No. 977 (1901); the third contains a description of the motor equipment of the trains. It was decided to run six-car trains instead of five-car ones as formerly, as a maximum during the hours of heaviest traffic on the more crowded portions of the system. A schedule speed of 14·7 miles an hour was decided on for the local service, based on an average of three stoppages in the mile. This is a considerable improvement on the former steam service, with which the lighter trains had an average schedule speed of only 12 miles an hour. The weight of a six-car train fully equipped and loaded is about 154 tons. The train characteristic was based on an average distance of 1,775 feet between stations, to be traversed in 68 seconds. It was laid out with power on for 30–35 seconds, and with brakes on from 10–12 seconds, the balance being spent in drifting. This would accelerate the rate of 1·3 miles per hour per second until a speed of about 16 miles per hour was obtained. The rate of brake retardation was assumed to be about two miles per hour per second: this allowed for an average consumption of 17 watt-hours per ton mile. The friction losses, estimated at about 12 lbs. per ton, and the acceleration of the rotating parts, together worked out to an amount equivalent to an addition of 20 tons to a 154-ton train, and it was found that the service would require motors of about 800 h.p. per train.

It was at first proposed to operate each train with two motor cars, one at each end of the train, and four trailers, each motor car to be equipped with four motors. In this system, known as the "double-ended" system, a single main-conducting wire is run between the front and rear cars, the four motors being connected in parallel between it and the ground. The controller in the leading car operates in the usual series parallel way, connecting the four motors first in series and then in parallel. For reversing, an electrically actuated reversing switch is used in the rear car, connected by small controlling wires with the leading car. Each motor car has a controller at one end, each being capable of handling the eight motors. The method, however, is open to three objections: (1) the two large controllers occupy valuable seating space above the car floor; (2) each motor car must carry sufficient rheostats for the control of the eight motors, half of the rheostats being normally out of service; (3) complicated switching is required in making up trains. The proposed use of the "double-ended" system was therefore abandoned in favour of what is known as the "General Electric 'Type M'" system of control, which has proved satisfactory in an extended trial on the Brooklyn Elevated Railway. In this system each motor car is equipped with a series parallel controller, consisting of a number of magnetically actuated contact-making and reversing switches. The "contactors," as the former are called, together with a reversing switch, are equivalent to the usual controlling cylinder, but with the advantage that they do not have to be combined in one case, and may therefore be distributed in convenient positions under the car floor. Each Manhattan motor car has 13 contactors, equivalent to 5 notches in the series and 5 in the multiple position in the ordinary form of controller. Forcible rubbing contact on closing, and a large spring pressure, to give a quick break on opening, are obtained by means of knuckle-jointed movable contacts, the remainder of the opening being effected by gravity. Magnetic blow-outs are employed. The actuating magnets are connected to 9 wires formed into a cable, which is made continuous by couplers between the motor cars and the trailers. These wires are connected to small master controllers at each end of each motor car, and these are connected to third-rail shoes and to the ground, and the operation of any master controller energises the magnets of the contactors successively as desired. The master controllers are fitted with the so-called "dead man" handles, in which a spring-operated auxiliary controller cuts off the power from the train-controlling cable if the motor man moves his hand from the handle. The contactors will then open by gravity, and cut off the power from the motors. With this system two motors are used on each motor car, and a six-car train consists of four motor cars and two trailers, generally made up as follows: (1) Motor car; (2) trailer; (3) motor car; (4) motor car; (5) trailer; (6) motor car. When a six-car train arranged in this manner is divided in the middle into two three-car trains, each component will have a motor car at each end, so that no switching will be necessary at the termini. An additional advantage of this system is the better distribution of load obtainable, with a consequent increase of the possible tractive effort. The motor cars are of the unsplit box frame type, the field frame consisting of a single elongated steel casting of square external section, into which the armature is inserted through a circular opening in one end. The axle boxes are bolted to one side of this casting. The weight of the motor complete with gear and gear-case is about 4,300 lbs. The type has the advantages of great rigidity, with exceptionally extensive bearing surface for the armature, without sacrificing the length of either the armature or commutator. The ventilating openings in the frame are exceptionally large, and it is intended, on account of the dustless character of the Manhattan service, to dispense with the usual cover plates. The armature is built on a hollow spider, with spaces between the laminations, giving ventilating ducts similar to those of a continuous-current generator. It has 39 slots and 195 segments, there being one turn per segment, and 25 between each slot. The fields are insulated with asbestos on metal frames, and the armature bars with mica. The gear reduction is 3·94, the ratio of teeth being 18 to 71. The efficiency is over 90 per cent. between 140 and 200 amperes at 500 volts. Eight motors, with an output of 200 amperes each, will give a six-car train of 174 effective tons, an acceleration of 1·5 miles per hour per second in place of the 1·3 required by the train characteristic. The train control system allows of the express trains being made up entirely of motor cars if desired, instead of with four motor cars and two trailers, which will allow of an increase in the acceleration, if desired, and also in the speed, which would otherwise be limited to about 40 miles per hour on the level. Each motor car is fitted with an air compressor and governor, the former consisting of a two-cylinder pump, coupled to a series-wound 4-pole motor of the same general construction as the train motor. The piston displacement is 20 cubic feet per minute at a speed of 300 r.p.m. The governor operates at any desired pressure between 80 and 100 lbs. per square inch, closing the circuit on a reduction of about 10 lbs. from the opening pressure. G. W. de T.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

614. *Sprague Multiple Unit System.* **F. J. Sprague.** (Elect. Rev. 49. pp. 969–972, Dec. 13; 1045–1047, Dec. 20; and pp. 1067–1068, Dec. 27, 1901.) —The article commences with a description of the electric elevated railway in Boston, and then gives a detailed account of the multiple unit system on which it is worked. Each car has a complete electrical equipment of motors with their controller, and the controller of each car in the train is worked by a single "master switch" in the front car. This master switch has six positions—the off or normal position, to which the handle is retracted by a spring, in case the operator lets go of it; three running positions for ahead movement, coast, series, and parallel; two running positions for back movement, coast, and series. The master switch is connected by a five-wire cable, running through the train, to three relays for coast, series, and parallel running, and to the two coils which actuate a reversing switch on each car. The relays complete the circuit of a pilot motor which turns the controller. Thus, if the master-switch be turned to the series position for running ahead, the coils of an electromagnet on the reverser switch turns this so as to connect up the motors for forward running, and at the same time actuates the series relay, whereby the controller is gradually turned by the pilot motor, and starts the train by gradually cutting out resistance. When all the resistance is cut out the circuit of the pilot motor is broken by a switch in the controller, and the train continues to run with the motors in series. The parallel relay acts in the same way, except that the controller continues to turn after the resistances for series running are cut out, and connects the motors in parallel, breaking the circuit of the pilot motor only when all the resistances for parallel running have been cut out. The coast relay reverses the pilot motor and returns the controller to its starting-point. There are two other relays, the "automatic stop" and the "throttle." The former is in the reverser circuit, and is therefore energised as soon as the master-switch is moved from its "off" position. If, intentionally or otherwise, the circuit of the master-switch be broken, the reverser returns by spring action to its "off" position, and the "automatic stop" drops, thereby reversing the pilot motor and returning the controller to open circuit. The "throttle" is operated automatically by the current in one of the motors; it retards or stops the forward movement of the controller at any desired current, and so can become an automatic switch for providing a definite rate of acceleration. If either the "throttle" or the "automatic stop" be in an open-circuit position, it is impossible for the pilot motor to move forward, though it can be reversed. The circuits working the pilot motor are supplied with current locally from the shoe of each car. The weight of a complete equipment for one car, including two master switches, one controller, relays, switches, resistances, connections, &c., but without motors, is 1,972 lbs. Each car on the Boston line weighs 59,000 lbs., and has 63½ per cent. of its weight on the drivers. It takes 550 amperes at a maximum, and starts with an acceleration of 1·8 miles per hour per sec. (0·8 m. per sec. per sec.). The maximum speed reached between stations is 46 miles per hour. The energy consumption per car-mile is 4·5 units. Four stations supply the line, having a total maximum capacity of 73,500 amperes at 550 volts [see also Abstract No. 1212 (1901)].

G. H. B.

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[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

615. *Calculations for Electric Railways.* (Street Rly. Journ. 18. pp. 548–556, Dec., 1901, and 19. pp. 45–53, Jan., 1902.)—The articles in question deal with the proposed construction of a railway between New York and Port Chester, and contain a large amount of useful information. The projectors of the proposed railway are under the necessity of proving the convenience and desirability of the railway, as well as of showing that it is practicable both electrically and financially. In this case they were opposed by several existing railways, who alleged in the first instance that the figures set out were incorrect and the proposed scheme impossible; but these allegations were subsequently retracted. The figures and calculations given in the present articles may therefore be taken as being correct; and as they were prepared on an extensive scale, they are of considerable interest. The proposed railway is 21 miles long, and it is intended to run express trains, covering the distance in thirty-one minutes, allowing for ten stoppages. A large number of curves are reproduced, as being part of the evidence of the promoters. The first shows the so-called speed and distance curves for a 400-ampere motor equipment, this being the size selected. From these curves it is possible to see the speed reached and the distance travelled at any time. Next follow similar curves for a 300-ampere motor equipment; but this was not found able to do the work in the allotted time. It may be added that both these curves show the results obtained on the level, and on various up and down grades, up to 2 per cent. The next curve shows the effect of coasting and braking, and gives the relations between instantaneous speeds and distances covered at any moment. The full braking power is taken as being equivalent to a retarding force of 150 lbs. per ton, producing a negative acceleration of 1·6 miles per hour per second. The differences of grade are also taken into account. Then follow two complicated sets of curves, showing the performances of 400-ampere and 300-ampere motor equipments, under varying conditions of gear ratio, allowing also for the difference between express and local trains, and giving coasting and braking curves, with the distances travelled in given times under the different circumstances. The last set of curves, nine in all, shows the variations of speed between the different stations on the line, the kw.-hours consumed on the various portions, the various inclines, distances, curves, &c., and in most cases these curves are plotted both for express, fast, and local traffic. All the curves are well reproduced, and fully explained in the text. It is impossible to analyse them; but the following may be taken as an example of the results shown. On a run between two stations of 1⅝ miles, with a train consisting of one car weighing 52 tons, the figures are as follows:—

		Express.	Fast.	Local.
Time consumed		2′ 32″	2′ 34¼″	2′ 54″
Kw.-hours		13·54	11·12	6·92
Kw.-hours per car-mile		8·34	6·85	4·26
Watt-hours per ton-mile		160	131·6	81·9
Mean speed in miles per hour		38·5	37·9	34
Percentage	Energy	100	82·2	51·2
	Time	100	101·6	113·2
	Speed	100	98·4	88·3

Further, estimates of working expenses, of the cost of construction, and of the probable receipts are given in considerable detail, and there is a verbatim report of the examination of the expert witnesses. The case was evidently got up with great care, and the articles will repay examination. W. H. S.

616. *Car Maintenance.* **T. Millen.** (Street Rly. Journ. 18. pp. 273–276, Oct., 1901.)—The mechanical department of the Metropolitan Street Railway Company, New York, deals with a total of 2,579 cars, exclusive of special sweepers, sand cars, &c. The author describes the conversion of the original cable cars for electrical operation, with illustrations of special features. The standard brake mechanism in use is arranged so that the brake shoes are pulled clear of the wheels by gravity when released. A movable step, operated by the motorman, to enable the car to pass other vehicles in crowded streets, and a reversible sign illuminated from the outside, are described. Every car is inspected daily on coming in from the street, and is overhauled once in two months. The white metal armature bearings are hardened and polished with a hydraulic broach, which has led to diminished wear. All overhauling and inspection is done from below over inspection pits. A. H. A.

617. *Magnetic Field Produced by the Nice Electric Tramways.* **E. Mascart.** (Archives Néerlandaises, 6. pp. 550–554, 1901.)—The observations described in this paper were made at the Nice observatory, which is situated at a distance, horizontally, of 530 metres from the nearest point of the Nice and Contes Electric Tramway, and at a height of 300 metres above it. The effect on the recording bifilar magnetometer was unimportant, consisting merely of oscillations of small period without any disturbance of the mean position. Distortion of the horizontal-force curves could therefore be almost entirely eliminated by means of suitable damping arrangements. This is in accordance with the theoretical deductions made by Rücker's method [see Abstract No. 1600 (1901)], but the vertical disturbance, amounting to a maximum of $\pm 6 \times 10^{-4}$ Gauss, with somewhere about 100 amperes flowing through the line, was several times greater than the possible theoretical maximum. The author attributes this mainly to the fact that the line of route has alluvial soil on one side and rock on the other, so that the assumption that the earth may be treated as a homogeneous conductor becomes wholly untenable.

G. W. de T.

618. *Magnetic Field Produced by the Paris Electric Tramways.* **T. Moureaux.** (Comptes Rendus, 133. pp. 999–1001, Dec. 9, 1901.)—Magnetic observations were taken at two observatories, 35 km. apart, but in the same latitude, near Paris. The Parc Saint-Maur observatory is nearer to an electric tramway than the other, the Val Joyeux, and in consequence has greater disturbances. The author tried, by damping, to prevent the sudden violent movements of the declination and other needles caused by the stray tramway currents. But this entire elimination was not obtained, as was found by comparison of the records of the two observatories at all times of the day and night (when the tramway was unused). The conclusion is reached that the horizontal and vertical components, as well as the declination observations of the Parc Saint Maur station, are influenced by the stray currents. [See also Abstract No. 2233 (1900).] P. E. S.

619. *Electrolysis by Earth Returns.* **A. Larsen** and **S. A. Faber.** (Elektrotechn. Zeitschr. 22. pp. 1038–1043, Dec. 19, 1901.)—Experiments were made on the tramway lines in Copenhagen to determine the leakage of current from rails to earth, and from earth to gas- and water-pipes. A line was chosen in which the return path for the current had necessarily to take a definite path through the rails or earth. The road was macadamised, and was opened at various points to admit of measurements on the pipes. Measurements were made at night when no cars were running, and a current, usually of 100 amperes, was sent into the rails at a fixed point from the trolley line. The current in the pipes was made by measuring the fall of potential by a reflecting galvanometer. Careful determinations of the resistance of the pipes were made. These gave a resistance per square mm. section and one metre length, of from 0·83 to 1·02 ohms; this is about the resistance of mercury, or seven to eight times that of pure iron. The pipes were cast iron of English manufacture. A current of 100 amperes was introduced at different points into the rails, and in each case measurements of the current in the rails and in the pipes were made about every 200 metres. With the current entering at one end of the line the total stray current at a distance of 1,080 metres was 14·8 amperes, and of this 7·45 amperes was in the pipes. With the current entering at the middle of the line (total length 1,210 metres), the stray current was 10 amperes, of which 6 amperes was in the pipes. The pipes measured were, for about half distance, a 9-inch water-pipe and a 6-inch gas-pipe, and for the rest of the distance an 18-inch gas-pipe and a 6-inch water-pipe. These were from 1 to 3 metres distant from the rails. When the current was reduced from 100 to 5 amperes the percentage leaving the rails remained exactly the same, as also did the percentage entering the pipes. The total resistance of the rails in the length of 1,210 metres was 0·014 ohms, giving a drop, at 100 amperes, of 1·3 volts. The greatest difference of potential observed between the rails and pipes was 0·74 volt. With cars running the currents in the pipes followed the movements of the cars. At one point the current in a 9-inch water-pipe had a maximum value of 2½ amperes, with an average of about ½ ampere. The paper gives very full particulars of all the tests, with plans and diagrams. G. H. B.

620. *Contal Electric Automobiles.* (Elettricità, Milan, 20. pp. 771–773, Dec. 7, 1901.)—Three types of car are constructed: a Victoria, weighing 1,050 kilos, and capable of a run of 80–100 km.; a phaeton, weighing 1,190 kilos, capable of running 130–140 km., with an 8-h.p. motor, and an omnibus. Their consumption is 70 watt-hours per ton-km. at a speed of 20 km. per hour. The motors, of Gasnier's type, weighing 96 kilos, have two armatures and two field magnets. The controller gives three combinations of these, and the efficiency is over 80 per cent. at all loads between 12 and 120 amperes. The Contal accumulators have pasted plates; a cell of 21 plates, weighing 13 kilos, has a capacity of 194 ampere-hours at a 5¼-hour discharge, and gives 29·3 watt-hours per kilo of total weight. G. H. B.

621. *Electric Automobiles.* **R. A. Fliess.** (Horseless Age, 7. pp. 46–51, 1901.)—Electric vehicles seem to operate more satisfactorily when not required to cover as many miles per trip as is required on an average of horse-drawn waggons at present in light delivery service. An electric automobile can be made to travel, say, thirty miles on one charge of its battery, but for commercial work any attempt to obtain such a mileage on one charge of battery as a regular thing would result in an unsatisfactory service. The longest single trip recorded in light-horse delivery service during a period of observation which extended over three months was 25·725 miles. Out of 165 observations the average distance covered per trip was found to be 12·05 miles. An advantage of this short-trip method of operating such vehicles is that the length of time required to charge their batteries after each trip is very much shortened, and it is possible by properly proportioning the work of each electric vehicle to make it cover more miles per day than is required on an

average of waggons drawn by horses. The author records an explosion which wrecked several of the cells of a car, due to a driver igniting a match near the battery box. On public-cab service, unlike a delivery service, the length of a trip on one charge of battery cannot be closely controlled, and is often lost by a vehicle's having to wait to have its battery charged. The present rolling stock equipment of the New York Electric Vehicle Company consists of some 300 vehicles of various styles, and the building now occupied as a station can accommodate at least 700 vehicles if it should be necessary. Three large American cities have over 650 electric vehicles, owned by three companies operating electric-cab services in them. Yet it is not quite four years since the first electric cab was placed in electric service. The maximum number of miles covered in any one day by a single cab is reported at 66¼. The greatest mileage made by any one delivery waggon during the month is 1,381 miles. M. O'G.

ELECTRIC LAMPS AND LIGHTING.

622. *Cooper-Hewitt Vapour Lamp.* (Elect. World and Engineer, 38. pp. 503–509, 1901.)—Particulars are given of this lamp from the patent specifications. Stress is laid upon conduction with and without an arc. This lamp depends upon conduction without an arc. Under proper conditions certain vapours and gases may be caused to remain in such a condition as to convey electric currents under the influence of moderate e.m.f.'s after a current has once passed. Materials vary as to their suitability for emitting light, and must be chosen according to their spectrum. Mercury vapour is suitable, but is wanting in red rays. Certain materials added to the lamp during manufacture make it possible to start the lamp with a moderate pressure. One such substance is sulphur and its compounds, for example, sulphide of mercury; also selenium and phosphorus with mercury. The tube containing the mercury and sulphide is heated and exhausted, when it is subjected to a current at high voltage. A sulphide differing from the ordinary red or black is formed, and when cool the tube may be worked with a much lower e.m.f. It is desirable to free the tubes from certain foreign substances, particularly oxygen. Iron is generally used for the electrodes. While being exhausted the lamp has applied to it a moderate e.m.f., such as 110 or 220 volts, in addition to the higher voltage, and as soon as current passes from the low pressure, as shown by a sudden intense luminosity, it is known that the process is nearly complete. When the lamp ceases to give off further foreign gases it may be sealed off. When a lamp is to be started without heating on low voltages, it has been found advantageous to surround the glass near one electrode with conducting material, such as foil, which is electrically connected with the other electrode. For alternating currents, two bands are used, one near each electrode. These bands reduce the effective starting resistance of the lamp, so that a lamp which without it will start only on a high-tension circuit will with such a band start on a low pressure without difficulty. When the lamp is once in operation the band does not seem to produce an effect to the same extent.

Several designs of lamp are illustrated. One of these consists of a tube about ¾ inch in diameter and 2 or 3 feet long, the upper electrode being an inverted cup of iron (generally the anode) and the lower electrode of mercury. Flickering is avoided by exposing only a small part of the mercury surface as an electrode. The self-regulation of such lamps depends upon the vacuum.

The conductivity of a gas depends upon the density, increasing as the density decreases to a certain point, and then decreasing. As the pressure increases with rise of temperature, *i.e.*, with increasing current, it is possible to select the pressure and form for radiation, so that the conditions are stable with a certain variation of voltage. W. R. C.

623. *Improved Apparatus for Arc-Light Photometry.* **C. P. Matthews.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 671–683, 1901.)—The author describes an equipment which shortens the process of arc-light photometry considerably, by using the method of producing, upon the photometer screen, an illumination proportional to the mean spherical, or to the mean hemispherical, intensity of the source. Similar methods are due to A. Blondel and to E. J. Houston and A. E. Kennelly (see L'Éclairage Électrique, 1895, and The Electrical World, 1896). The author's equipment was designed for the Photometric Laboratory of Purdue University, where it is now in satisfactory operation. The apparatus, while embodying certain features of Blondel's arrangement, combines simplicity of operation with adaptability to either open or enclosed arcs. The author describes in detail the theory of the method employed, and gives numerical examples for further elucidation. From the formula deduced it follows, that to produce on the photometer screen an illumination proportional to the mean spherical intensity of the source, it is necessary (1) to direct towards the photometer the beam of light which the eye of an observer would receive if he were to view the source at an angular interval of 15 degrees in a vertical plane, and (2) to reduce the intensity of the light in these directions in the ratio of the sine of the angle between the direction of view and the vertical. The method of accomplishing this is described by the author, by the use of a ring of twenty-four trapezoidal mirrors which direct the light to the photometer screen in the chosen directions, and by a polygonal glass disk composed of as many sectors as there are mirrors. These sectors are smoked until they give the desired absorption. The possible sources of error are considered, and the means of avoiding them indicated. An essential condition to the success of the method is that the photometer should receive light through any given sector from the image in the corresponding mirror and no other. This condition, the author shows, can easily be satisfied. After determining the constants for the mirrors, glass, rotating wheel, &c., and describing the other parts of the apparatus, the working equation of the apparatus is given in a very simple form. As a check on the accuracy of the integrating method, as compared with the usual method, the author gives the results of a test on an arc of the enclosed type. The value obtained from the Rousseau diagram is 308, that by the method described in his paper 319, an agreement within 3·4 per cent. Considering the difficulty in maintaining an automatic-feed arc under constant conditions during the time required to take the distribution curve, this agreement is very satisfactory. As an appendix to the paper, the graphical method of Rousseau is described and illustrated. [See also Abstracts Nos. 542 (1899) and 2347 (1900).] L. G.

624. *Crawford-Voelker Incandescent Lamp.* **F. Z. Maguire.** (Elect. Rev. 49. pp. 915–916, Dec. 6, 1901.)—This lamp has a filament of titanium carbide, and is bifurcated, the two ends of the filament being separated by glass, which prevents any discharge taking place at the higher pressures. They can be made for pressures as high as 500 volts. A report by H. C. L. Holden,

as the result of running 50 lamps, gives the efficiency as 2·535 watts per candle at starting, 2·845 watts after 500 hours, and 3·35 watts after 1,000 hours. W. R. C.

REFERENCES.

625. *Three-wire Distribution.* **P. Torchio.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 849–856, Nov., 1901.)—The author summarises the points for and against this, and makes elaborate estimates as to the saving of copper in towns. M. O'G.

626. *Organisation of Operating Department of Niagara Falls Power Company.* **P. P. Barton.** (Cassier, 21. pp. 179–205, Jan., 1902.)—A well-illustrated paper by the superintendent of the operating department. G. W. de T.

627. *Drawbridge at New Bedford, Mass.* **W. F. Williams.** (Street Rly. Rev. 11. pp. 843–846, Nov., 1901.)—A description of the construction and operation of an electrically worked drawbridge, carrying an electric railway connecting New Bedford and Fairhaven. W. H. S.

628. *Accelerometer for Tramway Work.* **F. B. Corey.** (Street Rly. Rev. 11. pp. 889–890, Dec., 1901. Paper read at the N.Y. meeting of the American Society of Mechanical Engineers, Dec., 1901.)—The author describes an instrument which appears to be identical with that devised by Kapp, and already noticed in Abstract No. 723 (1901). W. H. S.

629. *Manufacture and Testing of Incandescent Electric Lamps in the United States.* **B. V. Swenson.** (Cassier, 21. pp. 237–246, Jan., 1902.)—The paper contains an illustrated description of modern methods, together with historical notes. G. W. de T.

630. *The Burgdorf-Thun Electric Railway.* **H. Martin.** (Génie Civil, 40. pp. 16[illegible]–176, Jan. 11, 1902.)—This article contains a very complete description, with many sectional drawings and photographs of the railway, which was described in Abstract No. 765 (1900). G. W. de T.

TELEGRAPHY AND TELEPHONY.

631. *Portable Baudot Installation.* **G. Robichon.** (Journ. Télégraph. 25. pp. 317–321, Dec., 1901.)—The Baudot telegraph was described in Abstract No. 1461 (1901). This paper treats of arrangements of a temporary character, such as that at Dunkirk for the Czar's visit. Two quadruples are coupled and their two distributors are commanded by the same electromotor. One of the quadruples transmits by its four sectors, the other by three sectors, receiving by the fourth. If necessary, however, more sectors can be used to receive. Translators with their electromotors are utilised when required. The two coupled quadruples are on two lines going to the distant station, where they communicate with two quadruples of normal type independent of each other. For permanent offices large Callaud batteries have been used, but something light was called for in the case of portable offices. Hence the Daniell was fixed upon. A copper cylinder is the containing vessel, 4 cm. in diameter and 15 cm. in length, holding solution of copper sulphate ; in this stands a porous pot of parchment paper containing a zinc rod 7 mm. in diameter, with its solution of sulphate of zinc. The internal resistance is under 2 ohms. The battery of 20 to 25 cells, is emptied and refilled daily. E. O. W.

632. *Wireless Telegraphy.* **H. Poincaré.** (Bureau des Longitudes, Ann. 1902, pp. A.1–A.34.)—In the course of a general historical sketch, the author discusses the effect of the antennæ, and attributes their value in long-distance transmission mainly to the fact that the increase of diffraction with wave length enables the longer waves to turn obstacles with greater facility, and, for example, to follow the curved surface of the earth. This would be in accordance with the experimental facts that the Hertz waves are transmitted more easily oversea than overland, and that they do not penetrate to any considerable depths below the surface of the ground. [See Abstract No. 1016 (1901).] G. W. DE T.

633. *Telephone Cable with Self-Induction.* **F. Breisig.** (Elektrotechn. Zeitschr. 22. pp. 1046–1050, Dec. 19, 1901. Communicated by the Telegraphen-Versuchsamt.)—The Kabelwerk Rheydt A.-G. constructed a cable of 28 double conductors, seven 2 mm. in diameter, and the rest 1·5 mm. To increase the self-induction, the wires of each pair were separated as much as possible, and certain cores consisted of a copper and iron wire twisted together. The article describes measurements made on the cable of the resistance, self-induction, and capacity. For the 1·5 mm. iron and copper cores, the resistance was constant for alternating currents varying in frequency from 330 to 900 ∾ . The self-induction was 0·000422 henry per km., and the capacity 0·0644 mf. per km. For the 2 mm. iron and copper cores, these quantities were 0·00041 and 0·0852 respectively ; for the 2 mm. cores of copper only, they were 0·000296 and 0·0870 respectively. The values were found to vary considerably in the length of the cable. With suitable instruments, conversation over a length of 96 km. was satisfactory, and the authors consider the introduction of self-induction in the form described as a distinct improvement. G. H. B.